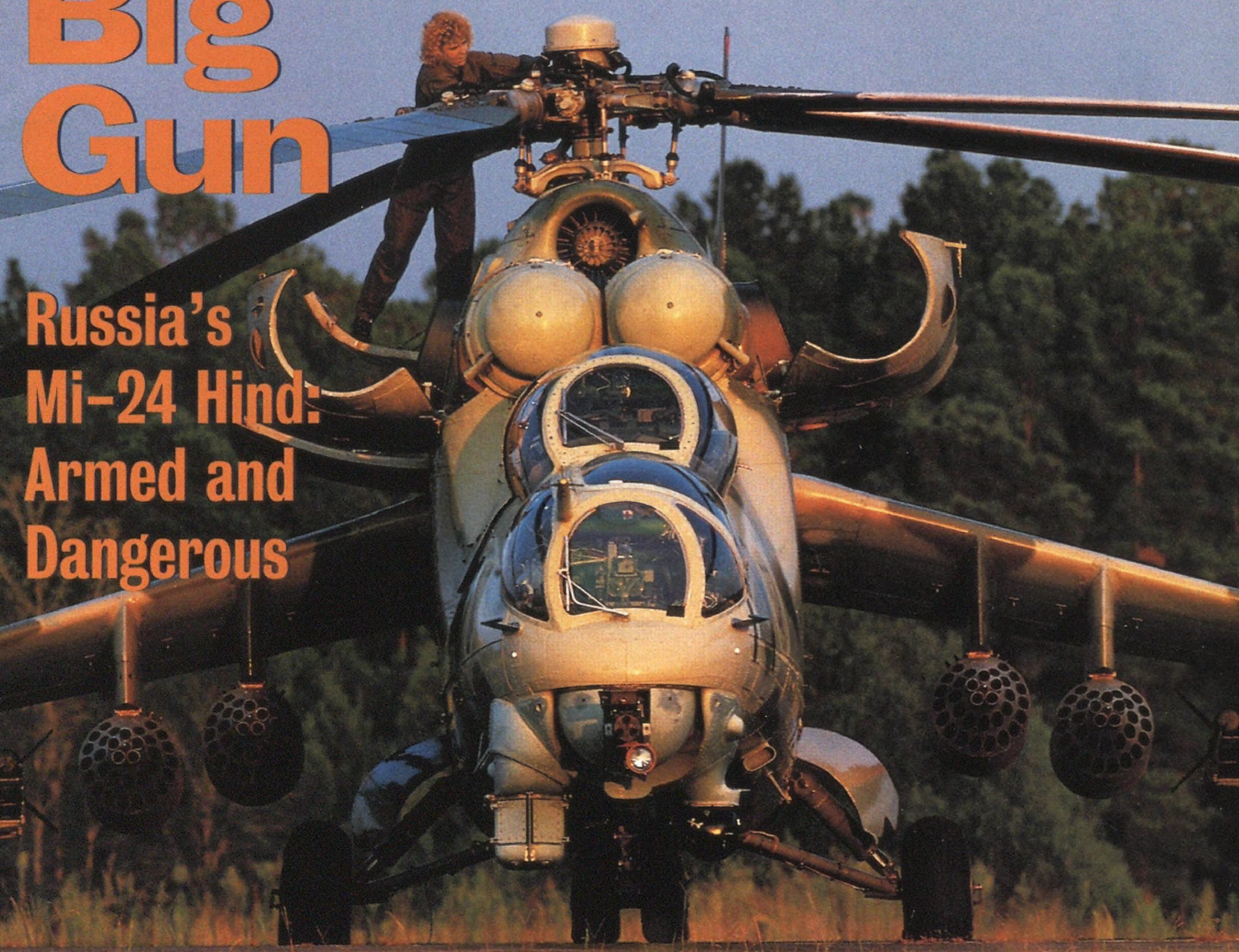
Midway II: A New Battle Looming?

AIR & SPACE

Smithsonian

Big Gun

Russia's Mi-24 Hind: Armed and Dangerous



MAY 1998 • $3.95 U.S./$4.95 Canada

05>

0 74820 08023 8

Once inside the all-new Navigator, you're likely to hear little more than your thoughts. Because for all its ruggedness, it's still a Lincoln. We kept it quiet with sound-absorbtion materials throughout the interior, coupled with an available air-suspension system and specially tuned shock absorbers

LINCOLN

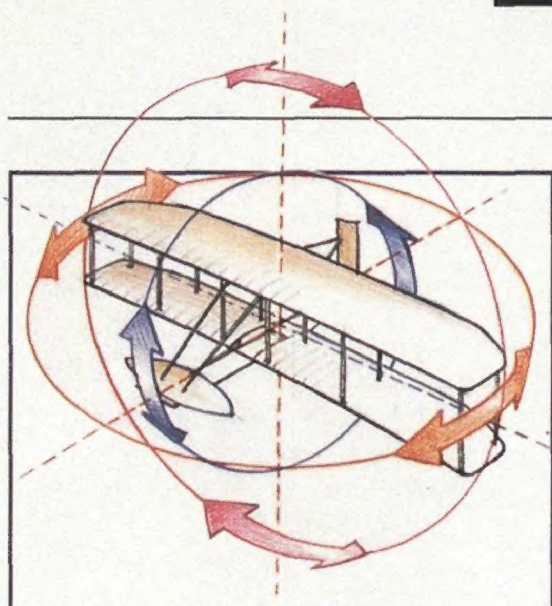
for a smooth ride. So you aren't likely to hear a thing, except maybe the call of the wild. For information about this full-size luxury SUV, call toll-free 1 888 2ANYWHERE (1 888 226-9943), visit our web site at www.lincolnvehicles.com or see an authorized Lincoln Navigator dealer.

Navigator from Lincoln. What a luxury [] should be.

April/May 1998
Volume 13, Number 1

AIR&SPACE

Smithsonian



Special Graphic Supplement:
The 1902 Glider
Illustrations by Bruce Morser

Most Americans probably don't know that the Wright brothers did not patent their 1903 Flyer; *they patented the 1902 glider. Here are the secrets to the glider's success.*

CONTENTS

62

58

Cover:
Mechanic Brenda Bachtel inspects the rotor hub of a Russian Mil Mi-24 Hind attack helicopter in this photograph by Chad Slattery.

Departments

AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560. Editorial offices: 901 D St. S.W., 10th Floor, Washington, DC 20024. Advertising and circulation offices: 420 Lexington Ave., New York, NY 10170.

SUBSCRIPTION PRICES: U.S. and possessions: $20 a year payable in U.S. funds. Canada and all other countries: add $6.00 (U.S. funds) per year. Eighty-five percent of dues is designated for magazine subscription. Current issue price: $3.95 (U.S. funds). Back issue price: $5.00 (U.S. funds). Periodical postage paid at Washington, D.C., and additional mailing offices.

MAILING LISTS: We sometimes make our subscriber list available to companies that sell goods and services by mail that we believe would interest our readers. If you do not want to receive such mailings, send your current mailing label or exact copy to: *AIR & SPACE/Smithsonian*, Mail Preference Service, PO Box 420113, Palm Coast, FL 32142-0113.

ADDRESS CHANGES AND SUBSCRIPTION ORDERS: mail to *AIR & SPACE/Smithsonian*, PO Box 420113, Palm Coast, FL 32142-0113; call 1-800-766-2149 (outside the U.S. call 1-904-445-4662); visit Web site http://www. smithsonianmag.si.edu; or go to the Smithsonian Online area of America Online (keyword: Smithsonian Magazine). Postmaster: Send change of address to *AIR & SPACE/Smithsonian*, PO Box 420111, Palm Coast, FL 32142-0111.

PRINTED IN THE USA

DIRECT FROM AN EXCLUSIVE ENGAGEMENT ON MARS.

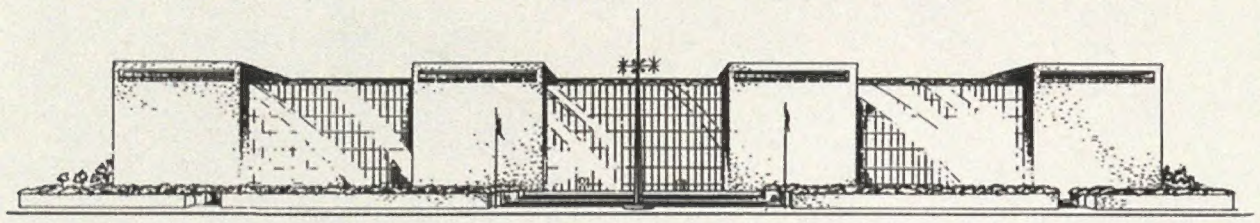
The world watched in awe as a 22-pound remote-controlled robot searched for life 310 million miles away. Now, the Hot Wheels Collectibles™ Sojourner™ Mars Rover,™ officially authorized by JPL, is available here on Earth. To have your 24K gold plated, limited edition shipped to you today, call Service Merchandise at 800 251-1212. Ask for item# 17987MT.

JPL

Actual size of model is approximately 3 inches in length.
SOJOURNER, MARS ROVER, and JPL trademarks are displayed under license from CALTECH.

Hot Wheels™ COLLECTIBLES

NZ088



The Envelope, Please

Like the Golden Globe and Oscar awards that honor stars of stage, TV, and screen, the Collier and Wright Brothers Memorial trophies honor achievements in air and space, and it's time again to choose the Collier Trophy winner for the past year. The Wright Brothers Memorial trophy winner will be chosen this summer. To win either award is a singular honor and ensures the winner—either an individual or a team—a place in air or space history.

The Collier and Wright Brothers Memorial trophies reside in the National Air and Space Museum, where they are revered, and selections of winners are conducted each year under the auspices of the National Aeronautics Association, keeper of all United States records for air and space. More than 30 representatives of aerospace communities come together and carefully consider those nominated for accomplishments during the past year. It is not a task taken lightly, and by the time you read this, the Collier Trophy winner will have been announced for the April 29 presentation.

The selection process is fair and fast, and in my experience over the past 16 years, it has always ended with a unanimous selection. The importance of the trophy is attested to by the names of the winners, from Glenn H. Curtiss for hydro-aeroplane development in 1911 to Cessna and the Citation X business jet team in 1996. All manner of air and space craft, engines, systems, and individual feats have been honored in between.

As I did my homework in February for this year's Collier Trophy selection, I reflected on just how far we as a nation have come in 94 years of powered flight. I also had a chance to think about how such technical achievements have become more and more complex.

The first six winners of the Collier Trophy were individuals who developed the basic elements for flight. Later, the U.S. Air Mail Service and the Army Air Service were the first organizations honored. Individuals who developed the metal propeller, the practical parachute, the diesel aircraft engine, and the first airplane with cabin pressure came later. Then we honored the development of air-cooled engines, the autogyro, the twin-engine transport, and worldwide air transportation.

In the World War II years, the Navy was awarded the trophy for training and the Army Air Forces for leadership. After that, the engineers and pilots who developed transonic flight, autopilots, and powerful jet engines were honored.

In 1959, the Collier Trophy began to consider achievements in space as well as aviation for the award. Since then, a balance has been maintained between the spheres of air and space. Today, astronauts, test pilots, and engineers are equally likely to share the Collier Trophy, and it retains its hallowed importance for recognizing achievement.

Since the beginning of the Space Age, the award has been more commonly given to groups. The fact that it now takes teams to solve the complexities of new developments is a sign of the challenge and the times. But as I consider how to cast my vote for this year's Collier Trophy award, I find myself thinking of individuals, who achieved so much through the process of discovery.

Sure, we are making great progress while our achievements seem far more difficult to reach, but we have lost the up-close-and-personal involvement of the past. Our honorees now wear business suits and carry laptop computers. Perhaps I date myself too much, but I miss the smell of sweat, oil, gasoline, and kerosene. I miss the direct involvement of that one person making the project happen. I will cast my vote for the Collier Trophy winner to the best of my ability. But I wonder, have we designed the individual out of aerospace?

—Don Engen is the director of the National Air and Space Museum.

AIR&SPACE
Smithsonian

Secretary of the Smithsonian Institution
I. Michael Heyman

Editor
George C. Larson

Executive Editor
Linda Musser Shiner

Senior Editor
Patricia Trenner

Senior Associate Editor
Perry Turner

Associate Editors
Karen Jensen
John Sotham
Diane Tedeschi

Photography/Illustration
Caroline Sheen

Design Direction
Phil Jordan
Gretchen L. Maxwell

Cover Design
Lasko Design

Publisher
Ronald C. Walker

Administration
Carey O. Randall, Associate Publisher

Advertising
Louis C. Kolenda, DEO LLC

Circulation
Liberta Abbondante, Director
Caroline Topak, Marketing Director
Elizabeth Hopkins, Planning Director
Andrea Sole, Fulfillment Director

Production
Sarah D. Kingsley, Manager
Sue Nixson, Editorial Production

Business
Shelia Perry Brannum, Manager

Founder
Walter J. Boyne

Publisher Emeritus
Joseph J. Bonsignore

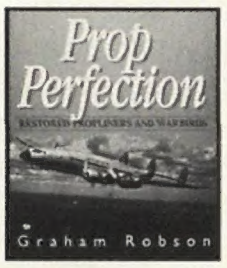
Contact information
Editorial: (202) 287-3733;
fax: (202) 287-3163
e-mail: editors@airspacemag.com
Advertising: (415) 454-9782;
fax: (415) 454-9785
e-mail: airspacemag@marinternet.com

ZENITH BOOKS Over 1,000,000 Books in Stock - Call Today

The Mighty Eighth: Warpaint & Heraldry

Freeman. A unique collection of original color photography specifically chosen to portray the colors and markings used to define the aircraft of the 8th AF. Filled with a unique range of emblems from every group and unit.160 pgs., 350+ color ill.

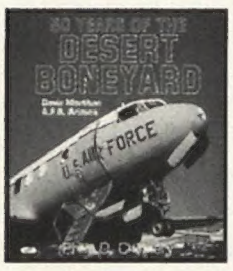
126723A . . NEW $34.95



Prop Perfection

Robson. *Subtitled: Restored Propliners and Warbirds.* A nostalgic look at the great warbirds and civil airliners still flying today. Detail shots reveal all aspects of the internal and external workings of these wonderful machines. 112 pgs., 120 color ill.

126233AP $24.95



50 Years of the Desert Boneyard

Chinnery. *Subtitled: Davis Monthan AFB Arizona.* A fascinating glimpse into the war-weary, battle-scared warbirds collected for 50 years at Arizona's Davis Monthan AFB. From yesterday's C-47s to today's F-16s, Chinnery leads you through the endless rows of fighters, bombers and reconnaissance aircraft layed to rest at Davis Monthan. 112 pgs., 156 color ill.

122269AP $21.95

German Aircraft Engines of WWII In Detail

Abanshin. More than 2,500 illustrations fully profile the legendary German manufactured engines of WWII. Included are engines from Daimler Benz, Junkers, BMW, Argus and Siemens, plus a special section on captured or license-built Czech and other foreign engines installed in Luftwaffe combat aircraft. 112 pgs., b&w ill., 16 color pgs.

125588B $49.95

Air Command

By Jeffrey L. Ethell. *Subtitled: Fighters and Bombers of WWII.* This incredible volume is actually two books in one. Inside is *Bomber Command*, the story of American bombers in WWII, and *Fighter Command*, the story of the American fighters that escorted them. Each cover the operations of the US Army Air Forces in the European and Mediterranean Theaters. *Air Command* relives the true color of the operations, the events and the planes. 356 pgs., 400 color ill.

127057N . . NEW $24.95
Available 4/15/98

Flying the Hump In Original WWII Color

Ethell & Downie. The capture of the Burma Road by the Japanese forced US airmen to fly 100's of missions a day across the rugged terrain of the Himalayan Mountains. Original color photos and exciting personal anecdotes reveal the massive scale of airlift accomplishments by US airmen. Exceptional! 168 pgs., 16 b&w ill., 167 color.

122148AP $29.95

Raiders of the Reich

Bowman & Boiten. *Subtitled: Air Battle Western Europe 1942-45.* Filled front to back with interviews from US, British and German aircrews describing their daring dogfights. Heroic stories of Allied fighter and bomber pilots flying into the heart of Germany and into the teeth of the mighty Luftwaffe. 224 pgs., 32 b&w pgs.

124635AP $29.95

Double Menace

McLaren. *Subtitled: P/F-82 Twin Mustang.* The Twin Mustang was too late to contribute too much to WWII, but went on to secure a significant place in aviation history by holding the line in the Korean War until enough jet fighters were available for service. McLaren offers dynamic coverage of this unique aircraft. 74 pgs., drawings, cutaways, 3-views & b&w ill.

120902C $16.95

American Eagles

Dick & Patterson. *Subtitled: A History of the USAF.* With photographs of the truly extraordinary airplanes and materials at the AF Museum at Wright Patterson AFB, you'll gain detailed insight into the monumental air combat of WWII, air combat in Korea and Vietnam, the designers, leaders, pilots, and other individuals who built the USAF and are taking it forward into the 21st century. 456 pgs., 240 b&w ill., 280 color.

125900C $65.00

Unexplained Mysteries of World War II

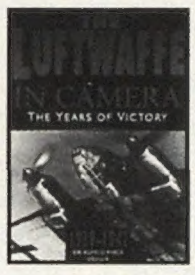
Breuer. Over 100 bizarre and baffling events, including the Ghost Pilot of Kienow, the life-saving candy bar, the mysterious fire on the *Normandie*, the suspicious magazine ad published weeks before Pearl Harbor, and more. 238 pgs., 46 b&w ill., 5 maps.

125637E $24.95

WWII War Eagles

Ethell & Bodie. *Subtitled: Global Air War in Original Color.* The ultimate coffee table book! From 1930s biplane Navy scouts and dive bombers to Messerschmitt Me 262A jets, these are the finest WWII color photos available, shot from 1939 to early 1946. Each photo features a detailed caption describing the scene and the aircraft. Includes virtually every type of WWII aircraft. 224 pgs., 225 color ill.

121482AE $39.95



The Luftwaffe In Camera 1939-1942

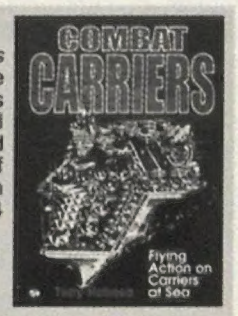
Price. This unique pictorial record covers the Luftwaffe's first three years of war and depicts its aircraft, operations, and men as they supported the German Army in spectacular victories in Poland, Denmark and Norway, the Low Countries and France, followed by the Battle of Britain in 1940 and the Blitzkreig on Russia in 1941. 180 pgs., 175 b&w ill.

126014AE $29.95

Combat Carriers

Holmes. *Subtitled: Flying Action on Carriers at Sea.* A full-color voyage through the experience of life aboard today's sophisticated aircraft carriers. Action-packed with deck shots as catapults steam and reheats roar - a deafening crescendo of sound and venomous technology captured in front-line attack readiness! 143 pgs., 294 color ill.

126609AP ..... NEW $29.95



The History of German Aviation

Wagner. *Subtitled: The First Jet Aircraft.* In Germany in August 1939, a small propellerless aircraft took off on its maiden flight under conditions of utmost secrecy: and with it the world's first jet aircraft. This work is filled with unique photos, historical documents, drawings and complete data tables. 260 pgs., 260 b&w ill. & line drawings.

126872C ..... NEW $39.95

Aviation: The Early Years

Almond. Chronicles the beginnings of manned flight in contemporary photos: giant zeppelins, bizarre engine-driven planes & bold pilots. Paints a vivid picture of an age marked by excitement and experimentation. English, German & French text. 360 pgs., 350 b&w ill.

NEW BARGAIN
126720C $29.98

Flying Legends

Dibbs. WWII triggered the greatest technological leap in aviation since manned flight began. In the short span of six years, military aircraft were taken from open cockpit biplanes to jet fighters! Shown in this volume are images of these legendary aircraft. The award-winning air-to-air photos of John Dibbs are complimented by a selection of archives from the conflict. 224 pgs., 85 b&w ill., 182 color.

126571AP . NEW $29.95

Aircraft of the Aces

Surviving aces provide unparalleled insight into the life of the fighter pilot in combat. Each volume contains up to 50 specially commissioned artworks, ace pilot listings, all-new scale plans and archival photos. Each is 96 pgs., 90 b&w ill., 18 color pgs.

Japanese Army Air Force Aces 1937-45, No. 13

Sakaida. A detailed text explains JAAF conflicts and tactics. Tables list the units involved.

124315AE $15.95

Soviet Aces of World War 2, No. 15

Morgan. Now that information restrictions have relaxed in the former Soviet Union, records of the deeds of the elite pilots of the Soviet Air Forces are coming to light. This text explains.

124317AE $15.95

Luftwaffe Secret Projects

Schick & Meyer. *Subtitled: Fighters 1939-1945.* With access to previously unpublished information, authors Schick and Meyer bring to life the furturistic shapes that might have terrorized the Allies had the war gone beyond 1945. Full color action illustrations in contemporary unit markings show vividly what might have been achieved. 176 pgs., 190 b&w ill., 95 color artworks.

124721B $44.95

WWII Pacific War Eagles

Bodie & Ethell. *Subtitled: China/Pacific Aerial Conflict in Original Color.* This fascinating book depicts the air war against Japan in the China-Burma-India, Aleutian and Pacific Theaters 1941-45. Each chapter describes a major area of combat and provides photos. 224 pgs., 225 color ill., 12 art sideviews.

123536AE $39.95

Allied Aircraft Piston Engines of World War II

White. Full details of significant technical developments that were incorporated into WWII aircraft engines. Chapters cover Rolls-Royce, Bristol, Napier, General Electric Turbosuperchargers, Pratt and Whitney, Allison and more, plus aircraft engine requirements, hyper activity and other near misses. 426 pgs., 315 b&w ill.

123304E $39.00

1-800-826-6600

FAX 1-715-294-4448 • OVERSEAS 1-715-294-3345

14-Day Money-Back Guarantee

Items can be charged to Mastercard, VISA, American Express, Optima, Discover. SHIPPING CHARGES are $4.95. The fee charged covers cost of shipping 4th class bookpost or UPS. We will ship the best way. NO CODs. Residents of CA & WI please add your state's sales tax. Prices & availability subject to change. We use many recognized names & descriptions that are the property of various manufacturers and other businesses for the purpose of identification only.

ZENITH BOOKS
PO Box 1 / AS048
Osceola WI 54020-0001

Send item numbers: _____ _____ _____ _____ _____ _____ Order Code: ASO48

Enclosed is my check or money order for $_____ U.S. Dollars

Charge to my: ❑ MC ❑ VISA ❑ AMEX ❑ Optima ❑ Discover

Account # _____ Exp. Date _____

Cardholder's Signature _____

Name _____

Address _____

City/State _____ Zip _____

AIR&SPACE
Smithsonian

LETTERS

Aircraft We'd Just as Soon Forget

I enjoyed "Gone but Not Remembered" (Feb./Mar. 1998), but either Bruce McCall or Major Bixby missed one highly forgettable aircraft: the Kola BROKE X1/2. The BROKE (Boomerang Return Observation Kinetic Energy) was an unarmed observation plane designed for the seas around Australia. On the trip out, its distinctive boomerang wing stored lift in collection tanks; when fuel was exhausted, the boomerang effect would enable the plane to return to base.

Of course, being Down Under, the return flight was made inverted. Unfortunately, after pilots adjusted to this position, they sometimes forgot to turn right side up to land.

—Rev. Winston E. Clark
Plymouth, Massachusetts

I'm afraid I've finally come across an *Air & Space* article I wish I hadn't bothered to read: "Gone but Not Remembered." To be blunt, it wasted the paper it was printed on.

—Sean Casey
Cranford, New Jersey

Weird-Winged Wonder

Looking at the F-16XL on the cover of the Feb./Mar. 1998 issue, I noticed that its wings were not symmetrical. Why is that?

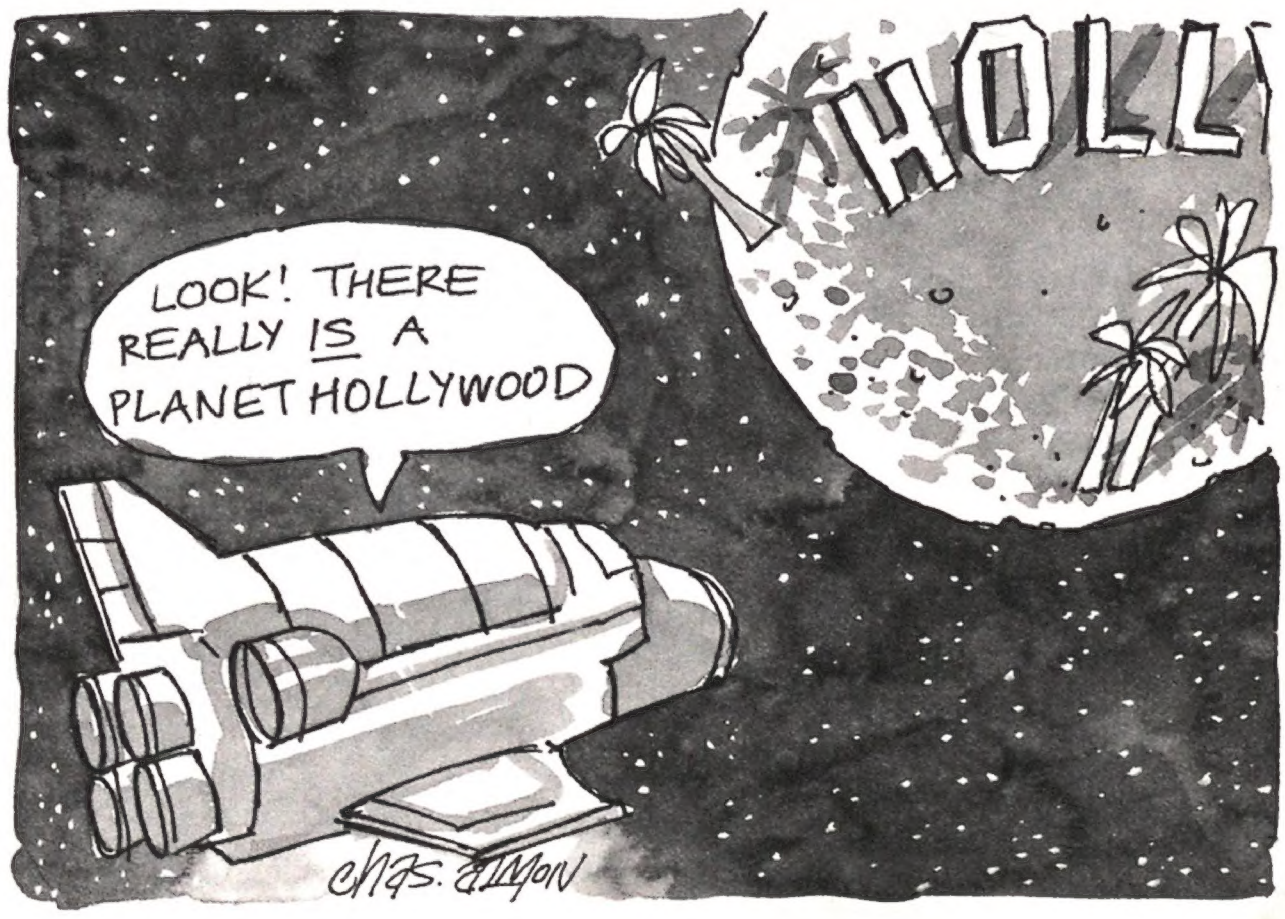
—Thomas Saltonstall
Cheshire, Connecticut

Editors' reply: The F-16's left wing had been fitted with a titanium glove that had millions of tiny holes drilled in it to draw in turbulent boundary-layer air. The project proved that laminar—smooth—airflow could be achieved over a major portion of a wing at supersonic speeds (see "Go With the Flow," June/July 1995).

Igor Sikorsky's Little Ruse

I was surprised by the photograph showing the propeller of the recently built Sikorsky S-16 replica ("Igor Sikorsky's Little Bird," Feb./Mar. 1998). The folks in pre-Bolshevik Russia were very sophisticated, but I doubt that they had Phillips head screws to use back then.

My father and Igor Sikorsky lived together in a one-room walk-up in their



early days in New York. Dad was the first U.S. employee of Sikorsky Aero Engineering. The two had known each other in Russia, and Sikorsky took my father for a flight during World War I over the submarine base at Kronstadt. The purpose of the flight was to see what Dad's new submarine looked like from the air, as German zeppelins were attacking him. The two devised a paint scheme to make the sub less noticeable in water. It must have worked, as here I am.

—Ivan L. Trofimov
Brookville, Ohio

Losing Our Focus?

I used to drive B-24s about 900 years ago, and I got a good look at number N24J when it showed up at Quonset Naval Air Station in Rhode Island a few years ago. I can't tell whether that was the B-24 in "Bomberville" (Feb./Mar. 1998). Whoever "enhanced" the photographs, perhaps by putting Vaseline on the enlarger lens, did not do the article a favor.

—Tom Pickering
Sarasota, Florida

Editors reply: Actually, the photographer achieved those effects by shooting the images with Polaroid film, then manipulating the film slightly as it developed. Since conventional photographs of B-24s are available in dozens of books and articles, we thought we'd offer something different: images that would evoke the aura of nostalgia that surrounds these well-loved aircraft as they tour the country.

Don't Get Your Hopes Up

In her review of *Mining the Sky: Untold Riches from the Asteroids, Comets, and Planets* (Oct./Nov. 1997), Nan Chase states: "Throughout the book, the message is clear: Space should be seen as Earth's biggest inexhaustible source of virtually free energy and other vital resources." I suspect people have made similar miscalculations throughout history, such as believing that the New World would be an inexhaustible source of coal, gas, petroleum, etc.

—Dan Harlan
Denver, Colorado

Corrections

Feb./Mar. 1998 "Igor Sikorsky's Little Bird": The S-16 was the first Sikorsky fighter, not the first airplane, with a synchronized gun-firing system. In addition, the photograph of the gun should have been oriented with the barrel pointing to the upper right.

"Seven Days at Dryden": Hydrazine does not contain oxygen.

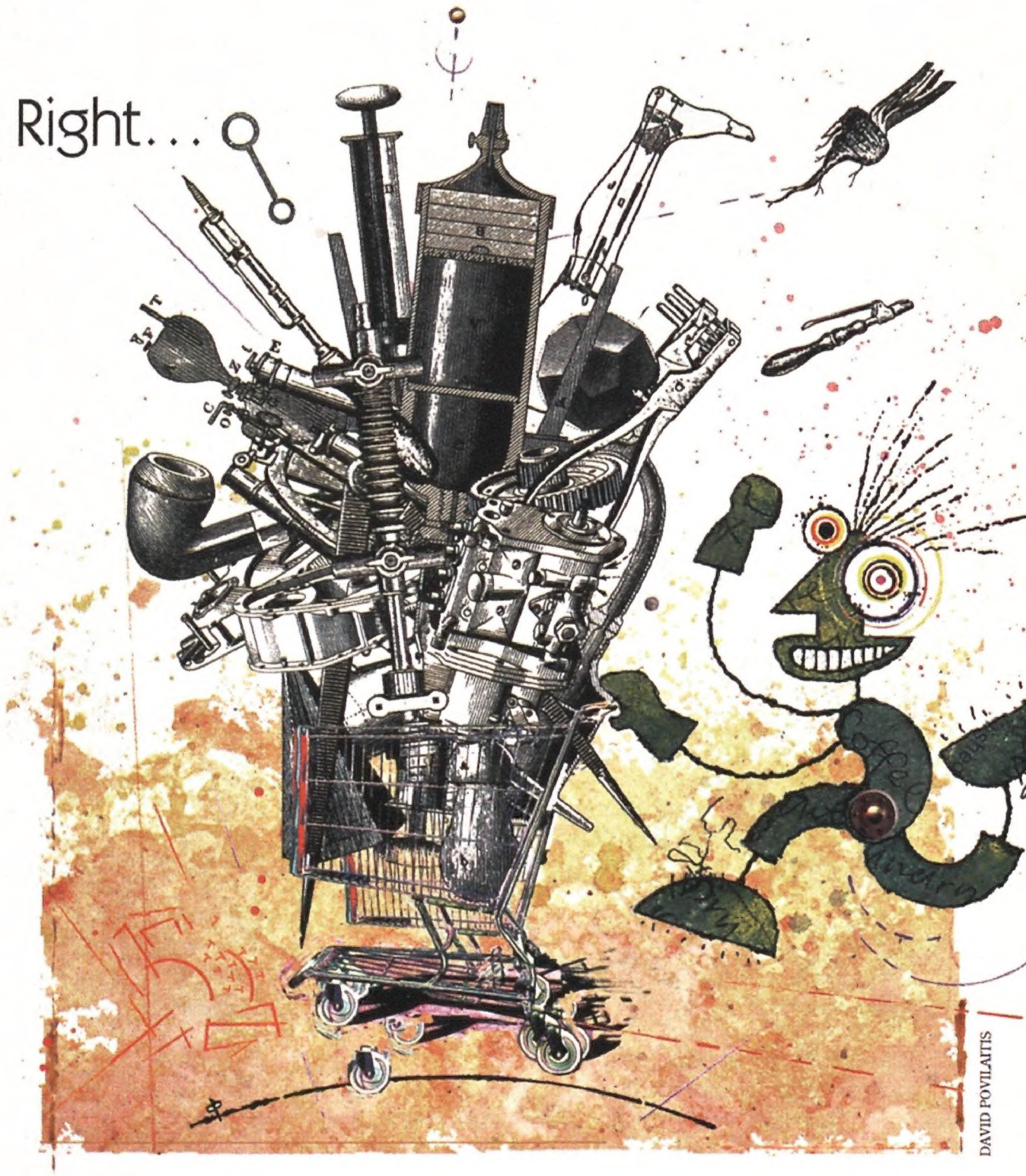
Reviews & Previews: We regret misspelling G. Harry Stine's name. *Living in Space* is Stine's most recently published book, not his last.

Write to us at: Letters, Air & Space/Smithsonian, *901 D St. SW, 10th Floor, Washington, DC 20024. Please type or print clearly. You must include your full address and daytime phone number. Letters will be edited for publication.*

Air & Space *is not responsible for the return of unsolicited photographs or other materials. We regret that we cannot answer every letter personally.*

e-mail *Send to* editors@airspacemag.com. *You must include your full name, mailing address, and daytime phone number.*

Where the Price Is Right...



DAVID POVILAITIS

It's a soggy Friday morning in the Seattle suburbs, but rain is no deterrent to the bargain hunters lining up outside the Boeing surplus store in Kent. Fifteen minutes before opening, some 40 people are huddled at the front doors. Another 30 or so sit in their cars, sipping coffee, awaiting first crack at the latest castoffs from the giant aircraft manufacturer.

The doors are finally unlocked at 10, and the crowd streams in, ignoring the NO RUNNING signs to attack the tool crib, dive into steel salvage tubs, and swim through a sea of used office furniture and computer equipment.

"This is actually kind of a light crowd this morning," says store manager David Levenson, eyeing a customer who keeps tossing a drogue chute into the air. "On Tuesday, the first day of the week we're open, we normally have 150 people waiting to get in."

What's the attraction? The biggest collection of second-hand junk in the state, maybe on the West Coast, including but by no means limited to reamers, cutters, air tools, shop gear, office furnishings, electrical and plumbing supplies, giant spools, shipping pallets, and casters bigger than your head. Every day, truckloads of used material and equipment arrive from Boeing plants throughout the Pacific Northwest, which are continually updated and retooled. What's not trashed or sold as scrap is sorted and put on sale, either in the store's 35,000-square-foot warehouse or outside on an adjacent three-acre lot.

The result is an enormous mosaic of the zillion items involved in airplane manufacturing, from rubber bands to huge aluminum sheets. The store does not carry finished aircraft parts, partly due to contractual obligations and partly because Boeing is wary of feeding the bogus-parts market. But everything else, no matter how old or obscure, seems to find a buyer.

"The most unusual thing I ever saw was a nose cone mockup bought by one of our regular customers," says Sallie Lofton, a 15-year store employee. "He never did get a chance to do anything with it, and eventually he passed away. I saw his wife down here, and she told me it's still sitting out in her yard."

A prime haunt is the tool crib, a fenced-in area the size of a large zoo cage, bristling with drill bits, cutting wheels, endmills, and various other chunks of burnished metal. "They say men don't shop," says Tracy Ulmer, a clerk weighing and pricing merchandise in the crib. "But they haven't been here."

Indeed, more than a dozen men are sifting intently through shelves and bins. In one corner, an old man perched on a stool is wearing bulbous magnifier goggles, the better to read tiny serial numbers and check for sharpness. At the other end of the cage, Al Levine from Olympic Northern Forest Products is examining a recessed cutter head. "There's only one of these," he says regretfully. "If there were four, I'd buy them."

Levine, who stops in monthly, could teach Tim Allen a thing or two about tools. "There's some stuff here you could never afford to buy anywhere else, like exotic metals," he says. "But some of the prices have gone up. Like electric air valves—I used to buy them here for $25 apiece. Now they sell them for $80 or $90,

and I can buy them brand-new for $120. So you've got to look around and be a smart shopper."

Used computer equipment is also a big seller, but for pure impulse buying nothing beats the cornucopia of tubs and bins at the front of the store, overflowing with hard hats, safety glasses, gloves, three-ring binders, tool bags, EXIT signs, knee pads, scissors, rolls of tape, sandpaper, and string. John McAllister, owner of McAllister Engineering Enterprises, strolls through the clutter pushing a shopping cart with a single bulky piece of gray machinery inside. "This is some kind of valve actuator I'll probably use for some sort of rotating mechanism," he says. "Actually, the only reason I come here is because I'm addicted and I have to get my fix every day. It's terrible when they're not open." What does he do then? "Slobber through the fence."

The store has even provided backdrops for TV shows. PBS science celeb Bill Nye was taken with a 12-foot rotating topographic globe, which Boeing hauled to his Seattle studio. And last year set designers from the cable sci-fi show "Stargate" descended on the store, eventually hauling away truckloads of futuristic-looking parts and machinery.

"I thought I recognized some of those pieces in their NORAD set," says Brad Lewis, who sells vehicles and other big-ticket surplus for Boeing. "We also had some two-handled glue guns that had a sort of Buck Rogers look. They bought a whole bunch of those. I'm waiting for them to show up in some big battle scene."

—Frank Kuznik

...And When the Price Is Wrong

A mixture of pilots, parts dealers, and curious onlookers from around the Midwest gathered last October at Smartt Field in St. Charles, Missouri, a small, well-tended airfield nestled in the fertile bottom land at the confluence of the Missouri and Mississippi Rivers. The smell of fresh coffee wafted through the hangar as women from the Missouri Confederate Air Force Auxiliary stood ready with a hot cup and a doughnut.

On the block, among a new Cessna 150 propeller, a box of used taxiway and runway approach lights, and some old shop manuals, was a mint condition, World War II Norden bombsight.

The bombsight was displayed in front of the auctioneer's podium, bolted inside a clear plastic case on a polished aluminum stand. The Norden's black crinkle finish appeared new, and its original logbook was next to the sight, which recorded a total of four hours of operation since manufacture.

At 11 a.m. things got rolling. Steven


GREGG LAIBEN

Douglas, founder of Douglas Auction & Liquidation, which specializes in aviation auctions, sized up potential bidders as he scanned the attendees milling around boxes full of parts only a mechanic could identify. In his sport jacket, he was out of place in a crowd primarily in quilted vests and ball caps. The PA system crackled with the auctioneer's chant, but the audience was clearly not the excitable sort—most items went for fractions of their original value. Some of the less desirable items didn't even bring a response. Douglas cajoled, "Come on folks, this is a deal!"

The crowd's lack of enthusiasm didn't sit well with Ed Hintz, whose Norden would soon go under the gavel. He meandered about the hangar during the bidding. A former B-25 bombardier who had aligned the crosshairs of a similar sight over Germany in World War II, Hintz began collecting Norden bombsights several years ago. "I bought my first one from a fellow in Ohio, sight unseen. Never met him. He was a bombardier too. We arrived at a price and he sent it out—collect." Hintz carefully unwrapped the package and "got a big lump in my throat." He now owns a collection of Nordens (he won't say how many).

Hintz was reluctantly parting with this particular Norden, a rarer version incorporating an advanced optical reflex sight, an improvement that allowed the bombardier to more accurately target from a greater distance. Hintz said the Continental Can company had the contract to pack up the obsolete sights in 1958. Many were sold for scrap for as little as 25 cents a pound.

After getting rid of some aircraft-grade leather dyed a 1970s orange and a complete lathe with accessories and tools that went for only $35, and after fielding anemic offers for some tired Cessna 150s parked outside, the auctioneer turned to the Norden. Douglas started the bidding at $2,000, causing a gasp. An assistant quickly responded with notice of a pre-auction bid from an anonymous party in Europe. Douglas called for $2,200, but the audience remained silent. An auction-goer wearing a camo-style hunting jacket muttered, "Too rich for my blood."

The bombsight garnered no bids at all from the crowd. The gavel fell, closing the bidding where it began. Anonymous got the sight for $2,100—not exactly like what happened at Sotheby's a few years back, when four bidders battled for another of Hintz's Nordens in an auction that helped fund the American Air Museum in Duxford, England. "The fellow got a heck of a deal on this one," Hintz said.

—Gregg Laiben

A Launch Down Memory Lane

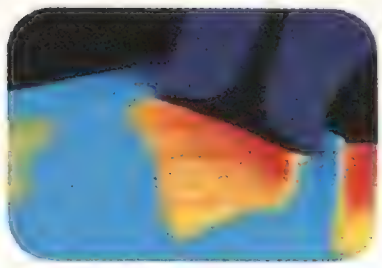
"Goldstone has the bird!"

Those four words were music to Sam Grimbly's ears. The bird was Explorer 1, and Goldstone was the tracking station in Earthquake, California, that listened for Explorer's radio signals as the United States' first satellite completed its first orbit of Earth.

Grimbly was a young Army sergeant, part of a team that launched the 31-pound spacecraft atop a modified Redstone missile at 10:48 p.m. on January 31, 1958.

Grimbly and his teammates had worked for weeks without rest, spurred by the embarrassment of Sputnik. Russia had orbited the world's first satellite the previous October and had repeated the

Power begets power. And our high-power digital engineering and testing capability has led to extraordinary gains in engine performance for the all-new Dodge Intrepid. Consider, for example, how much can be achieved when

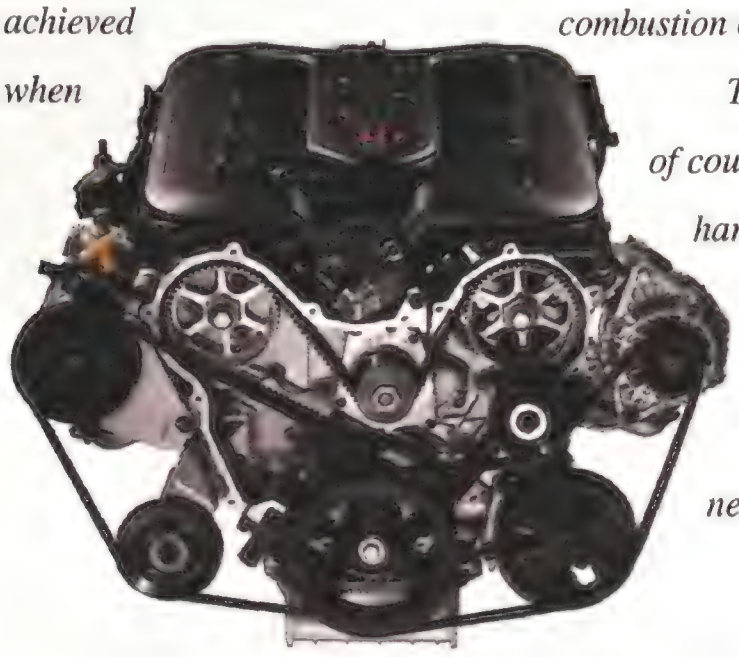


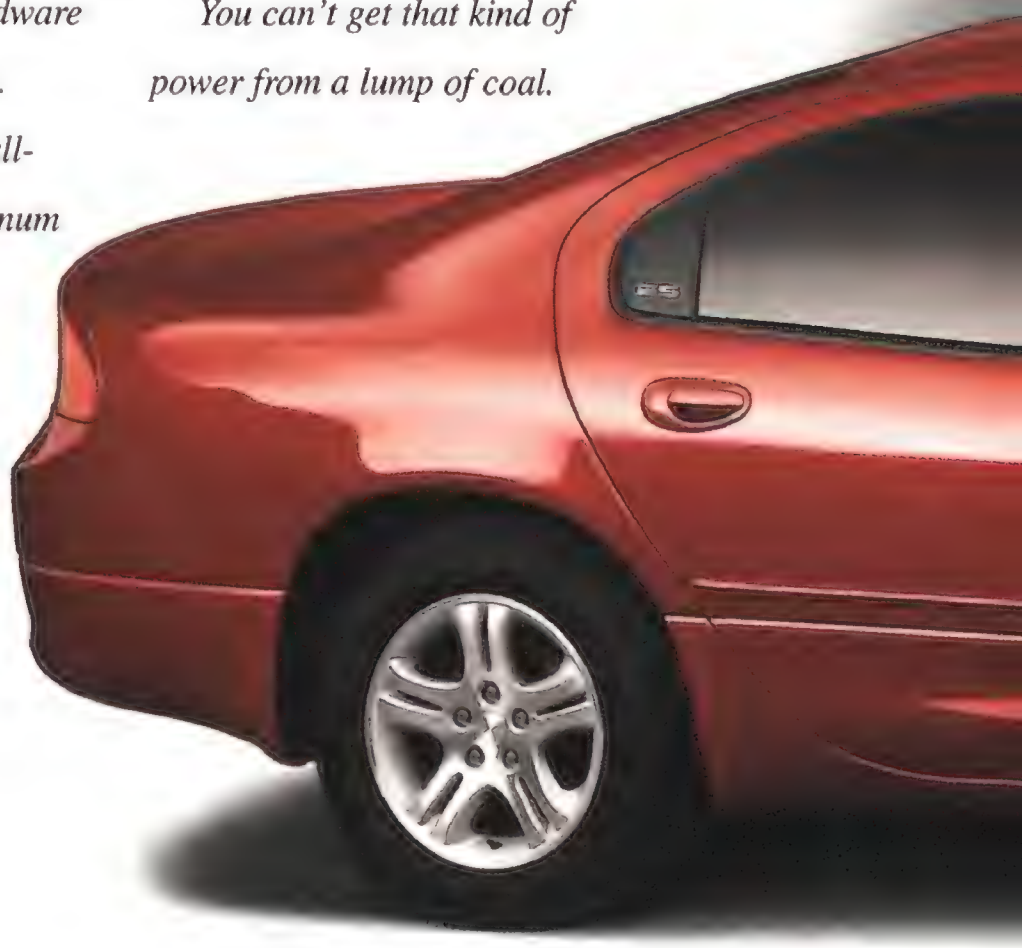
hundreds of intake manifold configurations can be tested instead of only two or three. Or how much can be learned when computer simulations accurately predict the behavior of gases in the combustion chamber.

The proof, of course, is in the hardware, and the hardware shines.

Our all-new aluminum 3.2-liter 24-valve V-6 develops a stout 225 horsepower at 6300 rpm on regular fuel. Our all-new 2.7-liter 24-valve aluminum, base V-6 generates an amazing 200 horsepower at 5800 rpm on regular fuel – more horsepower per liter than any other regular-fuel V-6 available today.

You can't get that kind of power from a lump of coal.





From a hunk, we cut a

Intrepid The New Dodge

For more information, call 1-800-4-A-DODGE
or visit our Web site at www.4adodge.com

# of aluminum 3.2-liter gem.

Always use seat belts. Remember a backseat is the safest place for children.

feat a month later with Sputnik 2, which carried a dog.

The Army had converted the Redstone, assembled the satellite, and launched the whole thing in just 84 days. "We didn't leave the pad until after it had made one orbit," says Grimbly. "Then we celebrated."

Now 75, with wife Pat on his arm, Grimbly is visiting Launch Complex 26 at Cape Canaveral for a coffee-and-doughnuts reunion with a few of his teammates at Explorer's 40th anniversary. The launch complex is now home to the Air Force Space and Missile Museum, and the sight of a preserved Redstone in its gantry sends the couple back in time.

Smiling Sam the Missile Man, as Pat used to call him, was one of about a dozen people who controlled access to the 70-foot-tall Redstone Jupiter-C. The closest Pat could get was the driveway of the couple's cottage. There she sat, shivering, in the back seat of their car, warming herself with coffee and a blanket, waiting to see a light on the horizon. "It took three days and three nights to get that launched," she says.

"It was called the workhorse of the missile fleet, the Redstone," she adds. "And the Navy had the Cadillac, which was the Vanguard. It flubbed, and the little thing fell on the pad and went beep, beep, beep, beep—"

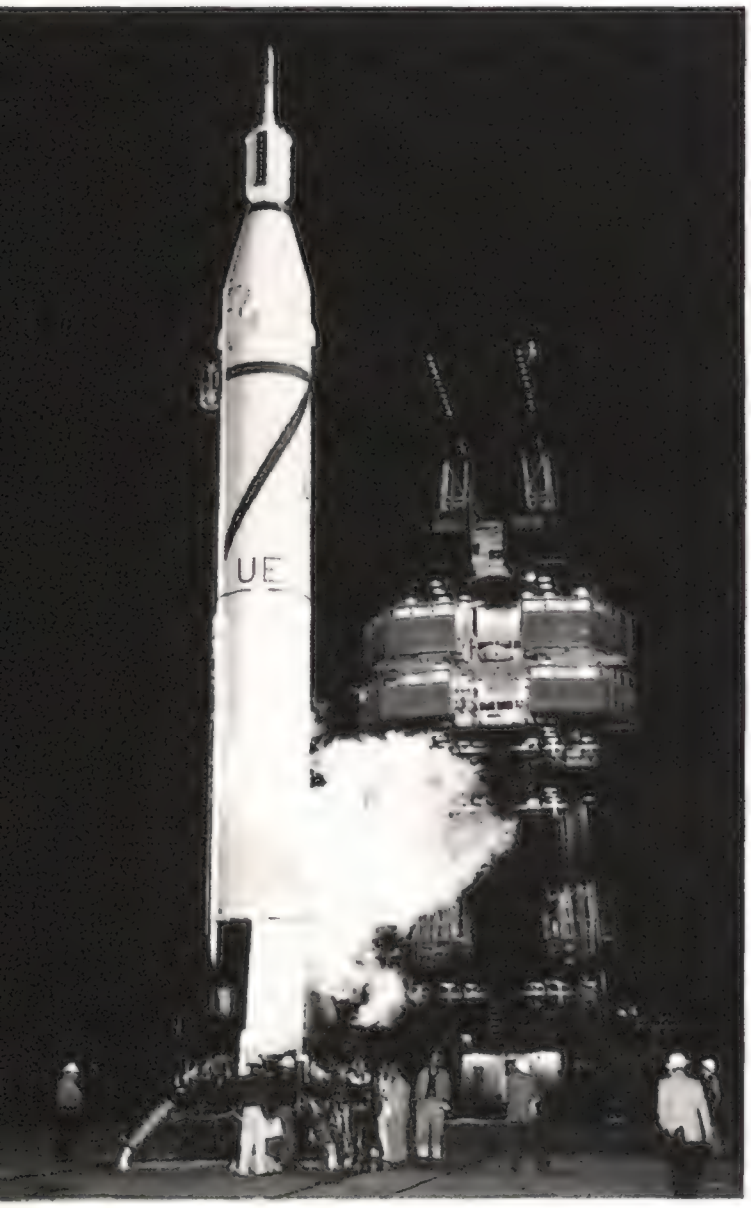
"Beep, beep, beep, beep," Sam interrupts, "running around the pad."

They're talking about the Naval Research Laboratory's hapless entry in the space race. Launched in December 1957, the Vanguard and its grapefruit-sized satellite got nowhere fast (see "The Day the Rocket Died," Oct./Nov. 1987). "It went up and it sat back down," Pat and Sam say, a scant second out of unison. "Broke in three pieces, and the grapefruit popped out."

The Vanguard grapefruit was little more than a tracking device. By contrast, a tiny instrument package crammed inside the pencil-shaped Explorer 1 made one of the most important scientific discoveries of the Space Age—radiation layers now known as the Van Allen belts. The data it gathered influences satellite design to this day.

Explorer 1 stopped transmitting when its battery died in May 1958, but the satellite traveled on for 12 more years. It reentered Earth's atmosphere and burned up over the Pacific in 1970.

—Beth Dickey



COURTESY SAM AND PAT GRIMBLY

Open-Mike Night on Mars

What is the sound of one hand scratching? In Martian dirt, with a robot hand? Janet Luhmann wants to know. She'd also like to know what the Martian wind sounds like, and Martian sandstorms, and Martian lightning, and anything else that comes within earshot of a microphone she and her team at the University of California at Berkeley will place on the Mars Polar Lander spacecraft, which is scheduled to touch down near the planet's south pole on December 3, 1999.

The Mars Microphone is two parts PR stunt and one part science experiment. At $50,000, it's a relatively cheap and easy way to add a soundtrack to those red-rock pictures we've all seen from Viking and Mars Pathfinder. "Part of exploration is man using all his senses to explore the universe," says Luhmann, a research physicist at Berkeley's space sciences laboratory. The sounds will be posted on the Internet for all the world to hear.

The impetus for the experiment came from Planetary Society co-founders Carl Sagan and Louis Friedman, who met with NASA officials in 1996, the year Sagan died, to persuade them to include the microphone on the next available flight for Mars. After NASA gave its blessing, the society raised the money from its members and hired the Berkeley team, who bought a hearing aid microphone from a catalog, rigged it with electronic controls, and sent it off to be integrated with a light radar (LIDAR) instrument that will go on the lander. The microphone assembly is about the size of "two boxes of Tic-Tac mints side by side," says Luhmann.

During its three-month mission on Mars, the mike will sample the ambient sound in 10-second snippets, with loud noises overwriting quieter ones that have already been recorded. Every week or so, whenever the project can spare precious downlink time (scientists for the lander's main instruments get pretty grabby about such resources), the snippets will be relayed to Earth.

What are we likely to hear? Sand grains pelting the lander, perhaps the sound of lightning-like electrical discharges in the atmosphere, almost certainly the robot arm moving and digging down in the Martian soil, searching for water ice. Project engineers expect the microphone to be a handy diagnostic tool if something goes wrong with the arm.

The sounds will be fainter than what we would hear on Earth, since the air at the Martian surface is as thin as our stratosphere, with hardly any molecules to carry sound waves. The microphone team has been busy testing sounds in a special Mars wind tunnel at NASA's Ames Research Center outside San Francisco, which simulates the low-pressure

He's Baaaack!

Senator John Glenn will join the crew of the shuttle *Discovery* for STS-95, the mission due to fly in October, as a payload specialist ("Friendship 76," Soundings, Aug./Sept. 1997). Last February Glenn completed a 3-G spin in a centrifuge at Brooks Air Force Base in Texas, required of all shuttle crews, with no ill effects. At the same time NASA announced Glenn's flight, the agency said that Barbara Morgan, the elementary schoolteacher and backup for Christa McAuliffe, who died when *Challenger* broke up in 1986, would soon join the astronaut corps to train as a mission specialist. While not specifically reopening the civilians-in-space program that McAuliffe had been selected for, NASA chief Dan Goldin said the agency was "expanding the reach of the astronaut program" and that citizens of "different experiences" could apply.

atmosphere. On Mars, says Luhmann, a normal, conversational voice would sound like a whisper.

Spectral analysis of the sounds will help the scientists interpret what they're hearing, but it still is "very likely to be pretty difficult to figure out" what causes some of the noises, says Luhmann. Dust devils and wind storms they can predict. "What could be happening on Mars that's unique?" Luhmann asks. "We're being very open-minded about our expectations."

—Tony Reichhardt

Mach Two Times

"It's hard to overemphasize how important the D-558s were," said U.S. Air Force historian Richard Hallion. "It was an extremely productive research program that isn't as well appreciated today as it might be."

Last February 4, at least, the D-558s stood at center stage at NASA's Dryden Flight Research Center in Edwards, California, the focal point of a symposium on the D-558 program. Guests included four of the program's National Advisory Committee for Aeronautics pilots: Bob Champine, John Griffith, Stan Butchart, and Scott Crossfield.

Among the crowd of aviation enthusiasts was longtime Douglas designer Charles Delavan, who appeared to be getting acquainted, rather than reacquainted, with the NACA pilots. "I've never met any of these guys before," he confessed. "In fact, I never even got to see the planes fly."

By 1945, the aviation community had already set its sights on breaking the sound barrier. The Air Force gambled on a rocket-powered aircraft, the Bell XS-1. But the NACA and the Navy preferred a more conservative approach based on a jet engine.

Delivered in 1947, Douglas Aircraft's D-558-1 Skystreak was a straight-wing craft whose sleek fuselage earned it the sobriquet Flying Test Tube. "It was a beautiful, honest airplane and a lot of fun to fly," Griffith recalled.

But the jet couldn't power the Test Tube past Mach 1. So Douglas built a rocket-powered swept-wing derivative dubbed the D-558-2 Skyrocket. Initially designed to take off under its own jet power and employ its rockets only at altitude, the -2 was soon being air-launched from a B-29.

Butchart, who also flew D-558s, handled the mothership for dozens of air launches. "I had a gentleman's agreement with [the D-558 pilot]," he said. "If I had a problem with the -29, I'd get rid of him, and if he had a problem with his plane, I'd get rid of him."

Though it wasn't the first to break the sound barrier, by 1953 the Skyrocket had set unofficial speed and altitude records. At the symposium, Crossfield insisted he hadn't lobbied for a shot at becoming the first man to fly twice the speed of sound. As he put it, eyes twinkling, "I just dropped a hint to the Navy that wouldn't it be nice if we could whip Yeager's ass?"

On November 20, 1953, Crossfield flew a specially prepped Skyrocket—sanded, taped, polished, and cold-soaked—to Mach 2.005. Three weeks later, Chuck Yeager would go faster still in the Bell X-1A. But making history, even speed-record history, is a matter of timing as much as velocity.

—Preston Lerner

D-558-2 pioneer Scott Crossfield asked, "Wouldn't it be nice if we could whip Yeager's ass?"

CHAD SLATTERY

Not-So-Cheap Thrills

Longing to go beyond ballistic? Starting in 2001, appropriately enough, you'll be able to buy your own space odyssey courtesy of a tripartite venture that plans to launch the first of two commercial rides a week to sub-orbit.

Zegrahm Space Voyages and Incredible Adventures, two firms specializing in adventure tourism, joined forces about a year ago with Vela Technologies to build a spacecraft that can take six customers to almost 65 miles above sea level. At that altitude you'll be able to float in a zero-G environment while viewing Earth in all its curved glory.

According to Scott Fitzsimmons, vice president of Zegrahm, the idea was a natural outgrowth of what he describes as a booming business with loyal clients. "They had traveled with us just about everywhere in the world and finally started to think about going into space," he says.

All that was needed was a marketing plan, which Zegrahm and Incredible Adventures developed jointly. And, oh yeah, a vehicle—which Vela has already designed and dubbed the Space Cruiser, to be built by AeroAstro. "It looks like a high-end business jet with rocket engines," says Fitzsimmons. "We expect to have a prototype within a year." None of the technology is new. In the words of Jane Reifert, president of Incredible Adventures, "It's just old stuff modified for passenger comfort."

Even the flight profile has a predecessor: NASA's X-15 program. A lift plane (also being developed by Vela) will take off from a departure point still to be determined, ferry the Cruiser to about 50,000 feet, and release it. Under rocket power the Cruiser then blasts up to max altitude—62 miles. Retro rockets eventually slow it down for a 2-G reentry, after which the craft returns to Earth under jet power.

All *you* need for the experience is $98,000. Which may seem a little astronomical given that you're only at max altitude a whopping two and a half minutes. "This is really just a first step," Fitzsimmons admits. "As we go on, we'll go up for longer times and probably even do orbits at some point. But you have to walk before you can run. Besides, we've had lots of people say they think the price is pretty good, all things considered."

Apparently so. Nearly 30 people from nine countries have plunked down a $5,000 deposit, which secures a reservation.

—William Triplett

Stellar Yardsticks

A powerful new piece of artillery has joined the arsenal of instruments used in the search for extra-solar planets.

Courtesy of a $35 million contribution by NASA and installation of a sensitive new device, the twin 10-meter, segmented mirrors at the Keck Observatory are now spending up to one-sixth of their observing time hunting for and studying planetary bodies. The telescopes, located atop Mauna Kea in Hawaii, are the largest in the world. Together, they make up an interferometer with a baseline of more than 250 feet, nearly 10 times the size of the Hubble Space Telescope.

The use of the Keck mirrors is the first in a series of efforts by NASA to build increasingly powerful instruments, both ground-based and in space, with the goal of someday photographing Earth-like planets orbiting distant stars. The efforts, called TOPS—or Toward Other Planetary Systems—will culminate with the launch of the Terrestrial Planet Finder, a stupendous interferometer some 325 feet wide, which NASA plans to park in deep frozen interplanetary space near Jupiter in the second decade of the 21st century.

Until then, searching for extrasolar planets remains a formidable task. Starlight is the great blinder of telescopes as far as planet detection is concerned. And even the giant Keck reflectors cannot see specks the size of planets around the nearest stars. So indirect techniques are being employed as the best immediate possibility for a discovery. The two primary methods available at the moment are spectroscopy and astrometry.

Spectroscopy is useful when a potential solar system's plane is nearly the same as our own—like looking at a compact disc edge-on. New spectroscopic instruments can detect small fluctuations in the Doppler shift of a star's light as its relative motion is altered by the pull of nearby bodies.

Astrometry is most effective at finding planets with long orbital periods, which shift a star's center of gravity very slowly. It's a method of detecting minute changes in the positions of stars, as they are pulled up and down or sideways relative to Earth.

Both techniques are being employed at Keck using a device called MAPS, or Multichannel Astrometric Photometer and Spectrograph. It is the joint brainchild of George D. Gatewood, director of the Allegheny Observatory in Pittsburgh, and Robert McMillan of the University of Arizona (see "The Planet Hunters," Oct./Nov. 1992). MAPS uses microscopic lenses and lasers to plot star motions with extreme precision. It compares phase shifts in the light waves of a target star with those of its neighbors, and compensates for the effect of Earth's motion.

The device also relies on a characteristic of optics called the isokinetic patch. It's an infinitesimal area of the sky about one arc-minute wide (one-third the width of a human hair held at arm's length) above the center of a telescope's viewing field. Gatewood discovered that observations conducted inside this area are virtually unaffected by distortions caused by Earth's atmosphere.

DAVID CLARK

UPDATE

Who Needs Interceptors?

The successful January 15 test of an infrared missile-tracking sensor launched from Kwajalein atoll in the Pacific ("Catch a Falling Missile," Dec. 1997/Jan. 1998) puts the National Missile Defense program on schedule for its first attempt to shoot down an ICBM this summer. But the test ended in what experts are calling a one-in-a-zillion coincidence. The third stage of the modified Minuteman II carrying the sensor's target was itself destroyed, apparently by a rogue piece of space debris. The Minuteman had been launched from Vandenberg Air Force Base in California more than 20 minutes earlier, and had already delivered the target warhead and a cluster of decoys used in the test. About 60 seconds before it was to reenter the atmosphere, the third stage suddenly disintegrated after tracking telescopes and radar showed it colliding with another small object. Although there may never be a way to prove it, the most likely culprit is an uncatalogued bit of space junk.

The patch permits crystal clear images, as if they were seen through a vacuum. When two stars are close together, MAPS can measure extremely fine variations in the distance between them. Over time, periodic motions can be detected, indicating that unseen bodies—possibly planets—are influencing the stars' positions.

The spectroscope part of the instrument is equally sensitive. It is able to detect changes in velocity as tiny as three feet per second, slower than walking speed.

Gatewood, a member of the NASA team supervising the TOPS effort, has been using the astrometry component of MAPS for several years on the 30-inch Thaw refractor at Allegheny. He believes he's already isolated a strong candidate star: Lalanda 21185, fourth nearest to the sun, located in the constellation Ursa Major. Something is tugging on it with an orbital period of about 35 years, so a bit more observation will be necessary before confirmation can be declared.

Installed at Keck, the power of MAPS should be improved by at least one order of magnitude over the Thaw instrument, Gatewood says. It's so precise, in fact, that the device should be able to detect objects the size of Neptune or Uranus—in the 30,000- to 35,000-mile-diameter range—and perhaps smaller. That's when astronomers truly will know they have discovered an extra-solar system, according to Gatewood, because objects that size are too small to be anything but planets.

—Phil Berardelli

Mini Driver

Riding atop pulses of light shot from a laser, tiny vehicles called Lightcraft are being propelled into the sky above the White Sands Missile Range in New Mexico in an attempt to establish a low-cost method of lofting satellites into orbit.

Sponsored by the Air Force Research Laboratory at Edwards Air Force Base in California and NASA's Marshall Space Flight Center in Huntsville, Alabama, the Lightcraft program uses the U.S. Army's 10-kilowatt pulsed-beam carbon dioxide laser, part of the High Energy Laser Systems Test Facility at White Sands, to launch the devices.

To the untrained eye, the 5.5-inch-diameter Lightcraft seem a cross between an orange juice squeezer and a giant acorn. As the name implies, they don't weigh much—typically between 1.8 and 2.1 ounces.

"They are all variations on the same theme," says Leik Myrabo, co-director of the Lightcraft technology demonstrator program. The craft harnesses the beamed energy from the laser and converts it to propulsive thrust.

Kilojoule pulses of laser light repeatedly strike the air in the business end of the Lightcraft, which is a cone-shaped concentrating mirror. Striking the parabolic mirror at 30 times a second, laser energy is sharply focused into a ring-shaped propulsion chamber. Blast waves are created as the air in the chamber is heated, propelling the Lightcraft. Says Myrabo, a professor of engineering physics who created the Lightcraft concept, "We're using totally clean propellant—air!"

"We're not inventing a lot of new things," says Franklin Mead, co-director of the Lightcraft experiments for the Air Force Research Laboratory's propulsion directorate at Edwards. "We're just combining a lot of technology that already exists."

Hundreds of horizontal and vertical guide-wire flights of the vehicle have taken place at White Sands since 1996, all leading to a first outdoor free flight last November. The Lightcraft rose to just over 50 feet in 5.5 seconds before smacking into a board at the top of the open-air test site structure. Admittedly, a modest beginning. But "we've proven the principle and we have proven it a number of times now," says NASA's John Campbell, manager of beamed energy propulsion research at the Marshall Space Flight Center. "The next step is to bring it to practical application," which entails boosting experiment-carrying Lightcraft to suborbital heights.

Monthly tests at White Sands have pushed the Lightcraft to ever-higher altitudes, with the record now at 73 feet. Once the vehicle reaches the 120-foot mark, halted by the plywood backstop, it will be readied for free flight—a series of hops to be coordinated with the U.S. Space Command to prevent a laser beam from blinding the sensors of a satellite that might be passing overhead during the experiments.

The team is eyeing use of a more powerful laser in storage at White Sands. Driver was built in the 1970s and can be brought back on line for $500,000, yielding power levels of 150 kilowatts. For another $500,000, a souped-up Driver that cranks out half a megawatt of power appears feasible. "That would drive us to the edge of space and, very possibly, get us into orbit," Myrabo says.

Ultimately, both the Air Force and NASA envision laser-lofting "pico-satellites" weighing only a few pounds. "We have sketched out a plan that puts us in orbit in five years," Myrabo says. "The success of that mission is predicated on getting Driver up and running."

—Leonard David

U.S. AIR FORCE RESEARCH LABORATORY

The Red Air Force's Black Death

German troops and tank crews shivering on the Eastern Front during World War II dreaded the sight of a crude-looking, low-wing aircraft they called the *Schwarzer Tod*, or Black Death. The Soviet Air Force's Ilyushin Il-2 Shturmovik, diving steeply from the sky and unleashing a stream of fire from two 23-mm cannon and two 7.62-mm machine guns, was one of the most formidable weapons used against the seemingly unstoppable *Wehrmacht* as it drove deeper into the Soviet Union.

The Germans developed a healthy respect for the crews of the heavily armored Il-2, who would often continue their attacks despite screens of horrendous anti-aircraft fire. The Shturmovik's fearsome weapons, which also included rockets and bombs, could decimate German armored columns and troop concentrations, but flying the Il-2 still required great courage: Early in the war, one Soviet Air Force Ground Attack Regiment lost 20 pilots in three days. Other units fared better—the 74th Ground Attack Regiment destroyed 55 tanks and 20 lightly armored vehicles in 700 missions flown during October 1941. Despite taking heavy losses themselves, Il-2 units were to inflict their damage over the course of the war through sheer force of numbers: More than 36,000 Il-2s were produced, a greater number than any other World War II aircraft.

What were once numerous are rare today. The National Air and Space Museum's Il-2M3 is the only example of a Shturmovik in the United States, and it is one of only two existing outside the countries of the former Soviet Bloc. The aircraft is on display at the Museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland, where it sits almost completely restored, tucked into one of Garber's nondescript buildings. "The only things that are not finished are the final markings and paint," says curator Tom Alison. "I'm still working on finding the exact history of the aircraft. The info I have is probably credible, but I have to be sure." The aircraft sits with its propeller and outboard wings removed, but it will be reassembled when it is moved to the Museum's Dulles Center, which will open in 2000.

ERIC LONG

Curator Tom Alison is researching the murky history of the Museum's Il-2 Shturmovik. During World War II, the Il-2 (right) terrorized German troops along the Eastern Front.

NASM

The Shturmovik was intended to be a low-level attack aircraft, or "flying tank," in the words of the designer, Sergei V. Ilyushin. The prototype first flew in 1940 and was being tested even as work was progressing on production versions at the State Aircraft Factory at Voronezh. With Germany threatening the western border of the Soviet Union, the need for the aircraft was obvious; by the time Germany invaded in 1941, nearly 250 Il-2s had been delivered. The Shturmovik's importance in countering the German army, particularly its tanks, was underscored by

Joseph Stalin, whose telegram to the Il-2 plant read: "The Red Army needs the Il-2 as it needs air and bread. I urge you to produce more Ilyushins."

The Shturmovik was built to survive the perils of ground attack; its forward fuselage was actually constructed from *bronekorpus*, or armor plating, which was four to five millimeters thick around the engine and its vital systems. Rapping knuckles on the armored nose is "like knocking on a bank vault," says Alison.

The Il-2 was designed to be a two-seat aircraft, but meddlesome military advisors decided the rear gunner was unnecessary, so the first production aircraft were built with only a pilot's seat. Shturmovik units suffered horrendous losses at the hands of Luftwaffe fighters, partly because many Il-2 pilots were untrained in air combat maneuvering but also because of a lack of rear protection. In 1942, a subsequent version, the Il-2M, was developed with a rear cockpit for a gunner armed with a 12.7-mm machine gun, but many crews operating the Il-2 had already field-modified their aircraft with a gunner's position long before the Ilyushin bureau approved the formal design for a two-seater. The addition of a rear gunner afforded some protection initially, and resulted in the downing of seven Messerschmitt Bf 109 fighters during the Il-2M's first missions. Once Luftwaffe pilots adjusted their tactics, however, Il-2s continued to suffer high loss rates. The gunners themselves were especially vulnerable: They were killed seven times more often than their pilots.

The Shturmovik at Garber bears few signs of its violent past. According to as-yet uncorroborated source material, the aircraft was attached to the Soviet Air Force's 211th Ground Attack Regiment. On March 15, 1944, Lieutenant Ivan Maksimovich Andreyev and gunner Sergeant Goncharov were flying the aircraft as they attacked German troops occupying the hills near the village of Pustoshka. After being struck by anti-aircraft fire, the Shturmovik crashed on the frozen surface of Kryakovsky Lake. Goncharov was killed but Andreyev survived and was taken prisoner by the Germans (he would later return to the Soviet Union after the war). As the ice cracked, the Shturmovik slowly slipped underwater.

The Il-2 had been on a list of aircraft most desired by the Museum for many years, but because so few exist today, there was little hope of acquiring one. The Museum finally got its Shturmovik after the downed Il-2 was discovered by a Canadian aircraft broker about five years ago and pulled from the lake where it had rested for almost 50 years. It was taken first to Finland, then to a repair facility in St. Petersburg, Russia, to be restored. Russian aircraft mechanics, some former Ilyushin workers and some who may have worked on the Il-2 assembly line itself, completed the work. The aircraft arrived at Garber with its horizontal stabilizer damaged in shipment. After repairs were completed it was placed in storage, where it will remain until the research is complete and the aircraft can be painted authentically.

Alison's main challenge is to determine whether the aircraft's history can be conclusively traced. The details surrounding its discovery and restoration are somewhat cloudy, so Alison is careful not to overstate his confidence in what he has uncovered so far. "As a curator, it's incumbent on me to find out exactly how the airplane was marked," says Alison. "If it turns out we have an aircraft made of several parts [of different origins], we'll then have an example of an aircraft type." In that case, the curator may recommend that the aircraft wear a paint scheme appropriate to an Il-2M3 but perhaps less specific to the history of the airframe itself.

Alison expects the aircraft to be painted while still at Garber. One day it will be displayed at Dulles in full unit colors, a testament to designers and crews who doggedly turned back the German army one tank at a time.

—John Sotham

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.

April 9 G.E. Aviation Lecture. "The Berlin Airlift: Operation Little Vittles." Flying a cargo aircraft over Berlin, Colonel Gail Halvorsen, USAF (ret.), dropped candy to the city's children. He will discuss his role as well as the entire airlift mission and its goals. Langley Theater, 7:30 p.m.

April 22 "Hot Off the Press! The Surface and Atmosphere of Mars." Phil Christensen, an Arizona State University professor, will share the results of the Mars Global Surveyor's infrared measurements. Einstein Planetarium, 7:30 p.m.

April 25 "Watching Washington, D.C. Change From Space." National Air and Space Museum geographer Andy Johnston examines the growth of the local metropolis through remote sensing. Einstein Planetarium, 6 p.m.

May 18 Gallery 103, which houses the *Enola Gay*, will close indefinitely for repairs.

ARTIFACTS

ERIC LONG

Two floats belonging to the Aichi Seiran, a rare submarine-borne attack bomber built by the Japanese in World War II, are undergoing extensive restoration at the National Air and Space Museum's Garber facility in Suitland, Maryland. Bob Weihrauch (left) and Derek Hodge are working on the removal of corrosion and replacement of the aluminum structure on the floats, a project that has been funded by Tamiya, Inc., a model kit manufacturer that recently issued a 1:48-scale plastic model of the Seiran.

The Return of the Lost Air Crew

Since their departure from Kunming, China, on a bleak January 1944 day, the already exhausted C-87 crew fought a constant battle with the elements. Shearing winds exceeding 100 mph blew them nearly 300 miles northwest of their course; ice forced them down below 20,000 feet. In the rare breaks in the cloud cover, the rugged Himalayas—known to airmen as the Hump—could be seen towering above the aircraft.

At the time, there was only one aerial route into besieged China, and that was over the Hump. For the Kuomintang forces of Generalissimo Chiang Kai-shek, who had been fighting Japanese forces in China since 1937, every class of supply from butter to bullets depended largely on young Americans and transport aircraft. Air crews took off from Allied-occupied Burma and India to thread their way across the Himalayan chain into Kunming and other unoccupied staging points in southwestern China.

The young airmen routinely faced treacherous flying conditions: More cargo planes—over 600—were lost on the airlift route than combat planes were lost fighting the Japanese in China. One of those transports was C-87 no. 41-223862, whose crew lost its battle with the weather and terrain that winter day and slammed into the side of a glacier.

For nearly 50 years, the location of the C-87 and its crew remained unknown. Then, in September 1993, a Tibetan hunter named Sherap Chopel, searching for game along a glacial moraine, noticed sunlight glinting off a metallic object. Curious, he worked his way down the steep slope and discovered that the object was the wing of a large aircraft. Wreckage of the airplane was scattered over several hundred yards of glacier.

When Chopel discovered human remains, all thoughts of hunting vanished and he began the five-day walk out of the valley. In his home village of Yigon, he and the village elders examined a piece of wreckage he had brought, and they gravely agreed: This was a government matter. They notified authorities of the

COURTESY WILLIAM H. JORDAN (2)

The author inspects a section of C-87 wing where it came to rest on an isolated Tibetan mountainside. The pattern of wreckage indicated a high-speed crash.

People's Liberation Army in the provincial capital of Lin Zhi, a day's drive from Yigon and 250 miles northeast of Tibet's capital, Lhasa.

The Chinese were alarmed. Was this a recent crash that had gone unreported? Could there be survivors trying to get out of the valley? Within a few days a hurriedly mounted expedition recovered remains of a crew and pieces of wreckage, and photographed and videotaped the site. In November, the People's Republic of China's Ministry of Foreign Affairs notified the U.S. Department of State through diplomatic channels. The information moved rapidly down through the Department of Defense and the U.S. Army to the U.S. Army Central Identification Laboratory, Hawaii at Hickham Air Force Base in Honolulu.

As CILHI's commander, I had returned from a trip to Vietnam, Laos, and Cambodia the previous evening. One site I had visited with one of our search-and-recovery teams, in northwestern Vietnam, was a few dozen miles south of China. This 1967 crash also lay in rugged, mountainous terrain in a remote area of the world, but as I watched the Chinese videotape pan up jagged, snow-wreathed peaks that ultimately disappeared in the clouds, the differences between the two became all too obvious.

As the scene changed to images of Chinese soldiers and Tibetan officials examining the wreckage, my thoughts turned, as they often do, to CILHI's solemn responsibility. America's search for missing U.S. servicemen began in the early conflicts of the 19th century and was formalized following the Civil War. Procedures for recovering, identifying, and interring American servicemen emerged from that bitter conflict and were refined through the Spanish American War and World War I.

Immediately following World War II, central identification laboratories were temporarily established in major regions of that conflict, and another, in Japan, was established after the Korean War. The organization that exists today in Hawaii has its roots in the Vietnam War and was established at Camp Samae San Thailand in 1973. The laboratory was moved to Hawaii following the fall of Saigon.

Although the approximately 150 soldiers and 30 civilians of the CILHI conduct recurring missions in Southeast Asia, the unit also maintains a search, recovery, and forensic identification effort for U.S. servicemen missing from World War II, the cold war, and, occasionally, Korea. Over 2,000 servicemen remain unaccounted for from Vietnam, and over 8,000 from Korea (approximately 6,000 of these are losses inaccessible in North Korea). Missing U.S. servicemen from World War II number over 78,000. In contrast to well-documented general locations of Indochina crash and burial sites, many World War II sites remain unknown and are usually found by circumstance, as this one was.

In December, a graves registration sergeant, an archaeologist, and I traveled to Lhasa, Tibet, with officials of the Chinese Ministry of Foreign Affairs and the American Embassy in Beijing. In a large meeting hall there we examined the items the Chinese had recovered.

The remains had been brought to Lhasa in three lacquered boxes, placed on a large examining table, and guarded with dignity by armed Chinese soldiers. As we opened the first box, sorrow washed over me. How quickly and violently this mission must have ended for these young men. As they and their aircraft lay undiscovered, a half-century had passed, and wartime friends had become enemies. More young men had fought each other in the bleak, snow-dusted mountains of Korea and the dank rainforests of Indochina. But good fortune and the innate kindness all people feel toward missing soldiers and their families had brought them here and, eventually, would return them to their homeland.

The Chinese had also recovered important artifacts from the aircraft. A data plate from an electrical assembly told us that the aircraft was a C-87, the cargo version of the B-24 bomber; tattered flight and maintenance logs narrowed the dates of the mission. The preservative effects of the cold were apparent when I examined a Thompson submachine gun that bore no evidence of rust or age. The remains of were remarkably preserved, in contrast to the handfuls of bone fragments we sometimes recover when we search jungle crash sites.

An honors ceremony on a gray day in Beijing saw caskets draped with American flags placed aboard an Air Force C-141B transport for the flight back to Honolulu. There, CILHI anthropologists would begin unraveling the mystery of the contents.

The remains were thought to be those of three individuals, but the exact aircraft lost and names of the airmen remained unknown until an important technical assist occurred. CILHI's senior anthropologist sent receipts from an officer's mess and a fragment of flightsuit marked with faded, unreadable letters to the Honolulu Police Department's crime laboratory, which raised two names under enhanced lighting. CILHI's World War II analysts then examined all Missing Aircrew Reports associated with C-87 losses in the China-Burma-India theater until they found a manifest bearing those names. The report also listed the names of three additional crew members. To account for the entire crew of five, we would have to return to the crash site.

Ten months later I stood in the Tibetan pre-dawn, steadying my binoculars and watching the second of three parties struggle up the glacial slope a mile away. Even in the mild September weather the wind cut through my jacket and sent a shiver through me. The mission had begun two weeks earlier, again in Lhasa, with a bumpy two-day drive across Tibet and a six-day hike up into the awesome valley in front of the glacier. Now, Sherap Chopel, the hunter, crouched next to me and spoke in Tibetan to Luo Zi Yun from the Foreign Affairs Office in Lhasa. "Mr. Chopel says that from here on it will be very dangerous until we get to the crash," Luo translated. "The glacier—how do you say—shifts and splits as it warms."

I had felt the spongy, permafrost earth give way in the two-mile pre-dawn hike from our base camp. To maximize the time at the crash site we had split our six Americans and 20 porters into three parties. Each would travel over a different route in case avalanches or smaller rock slides cut off one group or forced a different approach.

Through the binoculars, the first party was visible only as specks on the ice. Their mission was to get to the site first, establish the limits of the crash, and have priority-of-recovery tasks established when the rest of us arrived. Officials and porters in the final party, including Colonel Chen Yi Neng, commander of the security force, and myself, would carry the bulk of the equipment over a mile-wide field covered with glacial scree and boulders the size of small automobiles.

Five hours later we closed on the aircraft and began the tasks of mapping, sketching, and photographing the site. We used Global Positioning System equipment to determine the center of the crash and its limits. Our altimeters placed its highest point at 13,310 feet. Then we fanned out and started searching. After several hours we packed the remains we had found and other material possibly useful in making identifications into large canvas backpacks. The porters, for religious reasons, refused to carry the remains, so two American enlisted men shouldered the 80-pound loads and we began the long journey back to camp. (Only months later, after forensic tests were complete, would we learn that all five men had finally been accounted for. The crew was honored in a memorial ceremony at Arlington National Cemetery last January.)

The following day, we used a satellite phone to report the completion of the mission to Beijing and Honolulu. Then we struck camp and prepared to leave the valley.

Colonel Chen, with Luo interpreting, made a short but moving speech. "Chinese, like Americans, revere their lost servicemen," he said. "It was an honor for our soldiers to assist in this mission to recover friends lost as they fought with us many years ago. We will never forget them and we extend our sympathies to their families; we hope now they will find peace." Luo gestured into the mountains: "And that is a good omen for our mission and your journey back to your homeland."

Behind us a rainbow filled the valley. From where we stood, it appeared to be right over the crash site. I couldn't help gazing at it as we moved down the valley toward Yigon, Lhasa, Beijing, and home.

—William H. Jordan

Enhanced lighting revealed a handwritten name on this mess ticket, providing a clue to the identity of the C-87's crew.

Mission Accomplished

As a kid in the early 1930s I read a pulp magazine titled *Wild West Weekly*. In every story the good guy, wearing a white hat, got off his horse, went into a saloon, and shot a bad guy in a black hat. By the end of the story, thanks to his lightning-fast draw, he had shot a lot of guys in black hats. *Wild West Weekly* packed the power to bend a young mind bowlegged.

A year or two later I graduated to *G-8 and His Battle Aces*. World War I pilots didn't wear white hats but they flew SPADs against Fokkers, did chandelles and Immelmann turns, and dropped down to strafe an enemy that wore spiked helmets instead of black hats. Strafing I really liked.

On those rare instances when childhood fantasies come true, they come out different somehow.

Ten years after *G-8 and His Battle Aces* I found myself in twin-engine advanced flying school in Frederick, Oklahoma. Like most aviation cadets I had wanted single-engine advanced, so I could fly fighters, but in December 1943 there was an urgent need for bomber pilots. I clutched at a straw: Maybe I would get to fly A-20s, twin-engine attack bombers that did a lot of strafing.

I did not get assigned to A-20s. After graduation I went to B-26 transition school in Del Rio, Texas. Less than a year later, though, I was flying the Douglas A-26 Invader with the 555th Squadron of the 386th Bomb Group, part of the Ninth Air Force stationed in France and later in Belgium. After the B-26, the A-26 was a pleasure to fly, and it had great strafing potential. But my gunner in the turret in back was like no one in *G-8 and His Battle Aces*. He was a tech sergeant named Clark who had flown a full tour of 35 missions in B-17s out of England, gone back to the States as an instructor gunner, then volunteered for another combat tour. Before every mission, while he was helping me into my flak vest after I'd gotten into my seat, he'd say: "Get on the horn and wake me when we get to Germany." He'd go back to his turret and fall asleep. I wouldn't hear from him again until we were back on the ground.

At the time, A-26s—except for the glass-nose models used as lead airplanes—carried six .50-caliber machine guns in the nose and could carry four more under each wing, giving it a total of 14 forward-firing guns. With that much firepower you could knock a Republican off his platform, but I had flown more than a dozen missions in the A-26 before we got the word to drop down after a bomb run and strafe "targets of opportunity"—anything that looked like it had some military significance.

In early April of 1945, we all knew the war in Europe was nearing an end, and I wasn't especially mad at anyone, certainly not the farmers of Germany, who probably hadn't been reading newspapers when Hitler was coming into power. We had bombed something that was supposed to be an ammunition dump out in the middle of farmland, and when I dropped down to strafe, at an altitude of 40 feet or so, I found some open fields and got rid of my ammunition, triggering it out in short bursts where it wouldn't hurt anybody, not even a goat. I didn't think once about *G-8 and His Battle Aces*.

The intelligence officer doing the debriefing that day was a captain named Bob Meservey. He played first base on the 555th officers' softball team, and I played left field. His full name was Robert Preston Meservey, and in civilian life, as the actor Robert Preston, he had already starred in several movies, one of them an early wartime epic called *Wake Island*, which co-starred William Bendix and Brian Donlevy. After the war, he won lasting fame in *The Music Man* on Broadway.

RICHARD THOMPSON

In the debriefing line in front of me was a pilot whose name I don't remember, but he was from Wisconsin and had a lot of imagination that evidently had been repressed most of his life. He let it run wild that day and told Meservey all the targets of opportunity he'd caught with his guns—a troop train, a marshalling yard, and a couple of bridges, among other things.

When it was my turn I was deep-red embarrassed. I wanted to compensate for the poet ahead of me.

"What'd *you* hit, Ben?" Meservey asked. He had his pencil poised.

"Outhouses," I said.

"Outhouses?" he asked, deadpan. He could do deadpan better than anybody.

"Four of them," I said. "Not just possibles. Direct hits. I blew 'em away."

Meservey wrote down my answer and went on to the next man.

Two days later, as I came through the door of the debriefing room after another strafing mission, Meservey saw me and raised his head and his voice. "Here he comes," he announced with all his actor's resonance, "the scourge of the outhouses of Hitler's Third Reich."

Years later, when I had lunch with Meservey in New York, he was still calling me Scourge. I should have told him to check his six when he went to the men's room.

—Arnold Benson

NEW!

Smithsonian Poster

FERRARI MYSTIQUE

When Enzo Ferrari began his company 50 years ago, his cars were works of art, today they're collector's items!!

Smithsonian
MAGAZINE

1957 250 TESTA ROSSA PROTOTYPE

(Photo by Enrico Ferorelli as seen in our December 1997 issue)

This new poster measures 22" X 33" and is
available for only $20 plus $4.95 shipping and handling.

To order, Send $24.95 to:
Smithsonian Magazine
P.O. Box 23624
Washington, DC 20026-0624

Or to order online, go to www.smithsonianmag.si.edu and click on our KIOSK

The Thrill of Invention

by Tom Crouch

Photographs by Tim Wright

That's the 1901 Wright glider out there, darting about at the end of its kite tether 10 feet in the air. Up here on a great dune, whipped by the blowing sand and a wind gusting to 25 mph, one of the historic photographs taken by the Wright brothers seems to have come to life. The effect is stunning and a bit surreal.

In the old photos, the familiar figure of Wilbur Wright is stretched out in the open space in the center of the lower wing, his hand on the elevator control, his gaze fixed on the sandy slope in front of him. But the pilot I'm watching is a tall, athletic young woman clad in jeans and an A-2 flight jacket, her short golden hair swept straight back by the wind.

"She looks like a blond goddess," someone remarks.

"I like to think so," her father responds.

The intrepid aviator is Jacquelyn "Jay" Grattan, a twenty-something lawyer on leave

The only way to learn how the Wright brothers discovered the mechanisms for controlled flight was to discover them all over again.

Rick Young's replica of the Wright brothers' 1902 glider flew in 1997 above the dunes of North Carolina, evoking memories of the original. With his gliders, Young learned how the Wrights invented control.

from her duties as an officer and judge advocate with the U. S. Marine Corps. She has just become the first person since Wilbur Wright to fly the most discouraging, frightening, and instructive of the three historic gliders that were the final stepping stones to the invention of the airplane. And her aircraft is also the best replica of that glider that we are likely to see.

Back on the ground after less than two minutes of tethered flight, Jay is not pleased. "Pitch control is a struggle," she remarks to her father. "Now I understand why Wilbur and Orville were so worried about this one."

Jay is not a licensed pilot, but she can scarcely remember a time when the Wright brothers were *not* a part of her life. Her father, who is standing next to me watching her ride the wind, is Rick Young, a Virginia restaurateur with an abiding passion for the story of the two brothers from Dayton. Young has many years of experience building and flying reproductions of the gliders that led to the airplane as we know it today—a fully controllable flying machine. "Think about it," he explains. "The Wright brothers didn't even patent a powered airplane. They patented their 1902 glider. It embodied the lessons that were the foundation for the invention of the airplane, the critically important ideas that had to be protected."

At the beginning of their career in aeronautics, the brothers recognized that heavier-than-air flight would require wings capable of lifting the weight of machine and pilot into the air, a reasonably lightweight propulsion system, and a means of balancing and steering the craft in flight. "Of these difficulties," Wilbur Wright wrote in 1901 (compiled by M. W. McFarland in *The Papers of Wilbur and Orville Wright*), the first "two are to a certain extent solved." Balance and steering were the hard parts.

The brothers set out in 1900 to develop a winged aircraft that would, for the first time, be completely controlled by the pilot. To this end, they designed, built, and tested an evolutionary chain of four experimental aircraft, one kite (1899) and three gliders (1900, 1901, 1902), and conducted an important series of wind tunnel tests during the fall and winter of 1901.

It was not smooth sailing. Frustration and disappointment were as much a part of the process as the euphoria of discovery. As Young notes, "They were masters at the art of learning from their mistakes." And the gliders were the keys to their success, enabling them to find and overcome problems, to establish the basic principles of aircraft design, and most important, to learn to fly.

Young wants to rediscover the precise details of the Wrights' technology, and reproducing their gliders is simply a means to that end. "They had to translate their deepest insights and most important discoveries into the design and construction

details of those amazing gliders," Young explains. "And there is no better way to acquire a genuine grasp of those essential lost details than to build and fly accurate replicas of the historic machines."

Rick Young began his quest in 1975, when he and his brother Bill built a reproduction of the 1900 glider and flew it in a NASA promotional film entitled *Flying Machines*.

Rick Young (left) and Ken Hyde spend hours on research before they build. Here they check the hip cradle control on the 1903 Flyer.

The attachment point for the vertical strut on the 1900 glider/kite illustrates Young's painstaking attention to detail. By following the Wrights' inventive pathways, he has re-created a process for which there had been no existing record.

Five years later, Young began work on a reproduction of the 1902 Wright glider in his basement. Jay and her brother David were not yet teenagers when their father kited them aloft aboard that aircraft.

Over the next decade, Rick and his 1902 glider appeared in television commercials, on the Disney Channel, and as stars of the IMAX film *On the Wing*. The glider was exhibited at the Museum of Science in Richmond, Virginia, but was withdrawn and refurbished in 1994 for a role in *The Wright Stuff*, a film for PBS.

That same year, Young forged an alliance with Ken Hyde, an airline pilot and nationally recognized restorer of historic aircraft. A Wright Model B (see "What Makes It Wright?" June/July 1994) that Hyde's shop produced for the U.S. Army Aviation Museum at Fort Rucker, Alabama, also in 1994, is perhaps the finest reproduction of a powered Wright aircraft anywhere.

Hyde and Young were natural partners and formed a joint venture, The Wright Experience, in which they share a dedication to meticulous accuracy along with a goal of reproducing a full range of Wright aircraft. Hyde plans to build and fly another one or two powered Wright airplanes by 1999 or 2000. Young has reproduced all three of the Wright gliders, and Hyde and Young's first powered Wright airplane is under construction, with its first test flight scheduled for this fall.

The notion of telling the story of the Wright brothers through the experiences of two talented men determined to retrace the path to powered flight intrigued the producers of the television series "Nova." "Here was an opportunity to do something more than simply capture breathtaking images of Wright machines in the air," producer Michael Barnes says. "Although a little of that would be just fine, thank you very much." He and his colleagues at WGBH, the public television station in Boston, recognized a rare opportunity to walk viewers through the process of invention.

Young would refurbish and fly his existing 1902 reproduction. The 1900 replica originally built in the mid-1970s was long gone, however, and Young had never attempted to reproduce the 1901 machine. Research was the essential first step in building the new gliders.

Young searched for fresh information by carefully reexamining the surviving original photographs of the gliders. It's hard to believe, but only 12 of the 303 original Wright brothers glass plate photographs at the Library of Congress show the first two Wright aircraft.

Rather than attempting to work with the fragile originals, Young traveled to the Archives and Special Collections Unit of the Paul Lawrence Dunbar Library at Wright State University in Dayton, Ohio, where the Wright family collection of first-generation prints of the photographs is preserved.

After scanning these crystal-clear prints into his computer, Young could examine the digitized images with ease. In this way, he was able to understand the very different ways in which the fabric was applied to the wings of the gliders. He could also sort out the confusion of trussing and control wires barely visible in the photos. Even the size and shape of small fittings could be studied in detail and at leisure.

The replicas were built in a shop near Young's restaurant and at Ken Hyde's facility in the rolling country a few miles north of Warrenton, Virginia. Young started in the early summer of 1997 and finished in early October, when the three machines, along with considerable crew, traveled to Jockey's

Ridge State Park, four miles south of the Wright Brothers National Memorial and eight miles south of what was once the fishing village of Kitty Hawk, on the Outer Banks of North Carolina.

The largest sand hill in the eastern United States, Jockey's Ridge is familiar to the thousands of tourists who flock to the Outer Banks each summer. It still offers the combination of wind, sand, and slope that first attracted the Wright brothers to the Outer Banks in 1900. Had you trudged to the top of the great dune on almost any good-weather day last October, you would have found yourself transported back almost a century to the days when Wilbur and Orville Wright were testing their gliders.

For Wright glider pilots, the rule is "lighter is better." As a result, Young's wife, Sue, had performed much of the flying for the IMAX film. Rick was so determined to fly for the "Nova" cameras that he lost 40 pounds in the two months prior to the 1997 trials. Jay, who had flown for the PBS program, was on leave from the Marines and accompanied the team just in case she was needed. Both father and daughter had plenty of opportunities to fly.

Young and his crew flight tested each of the reproductions in turn, and three years worth of experiments were collapsed into three short weeks of combined flight testing and flying. The letters, diaries, notebooks, and photographs of the Wright brothers came to life for those of us who took part in the events unfolding on Jockey's Ridge. There was a sense of having shared some of the excitement that the brothers had experienced and of having come to a new understanding of the process of invention.

1900: The brothers started their active experiments in Dayton in July 1899, when Wilbur first flew a biplane kite with a five-foot wingspan designed to test a new approach to roll and pitch control.

At Ken Hyde's Warrenton, Virginia workshop, Rick Young and Greg Cone adjust the elevator for the 1900 glider, about which the least is known. Too small to carry a pilot, it was flown as a kite, controlled by four lines.

Before the Wrights moved their experiments to the North Carolina beaches, they flew five-foot kites similar to this replica of an 1899 model (right). It was their first attempt at true roll control.

Grand-nephew Wilkinson Wright observes as Dick Young, Rick's father, measures the wind speed at Nags Head with a handheld anemometer. The strong, steady breeze is what attracted Wilbur and Orville in 1900.

By manipulating two pairs of strings tied to the leading edges of both wings, the operator could shift the upper wing in front of or back of the lower wing's leading edge, or twist the two wings "so as to present their surfaces to the air at different angles of incidence and thus secure unequal lifts on the two sides," as Orville explained.

From the outset, the Wrights thought like engineers. In 1900 and 1901, they relied on data from German pioneer Otto Lilienthal to calculate the wing area required to lift the estimated weight of their aircraft at a particular wind speed. The brothers planned to test their first full-scale machine as a kite. They hoped that they would be able to fly "for hours at a time" tethered to the top of a derrick and grow accustomed to the wing warping and the use of the forward elevator to control pitch, "getting in this way a maximum of practice with a minimum of effort."

The 1900 glider featured ash ribs bent to shape with steam, but even during the short service life of the aircraft, the ribs gradually flattened out. On the way to Kitty Hawk, Wilbur had intended to buy 18-foot lengths of spruce to serve as wing spars. But he could find no lumberyard that carried spruce in that length, and he was forced to settle for white pine spars two feet shorter.

"The covering of the machine was French sateen [a closely woven cotton], and it was put on the bias, so that no wire stays were needed to brace the surfaces diagonally," Wilbur wrote. Applied this way, so that the fibers aligned like cross-bracing wires, the fabric became a key element of the structure, holding the ribs and spars in place and distributing flight loads across the wing. The result was a tough, flexible wing capable of absorbing punishment that would probably break a more rigid structure.

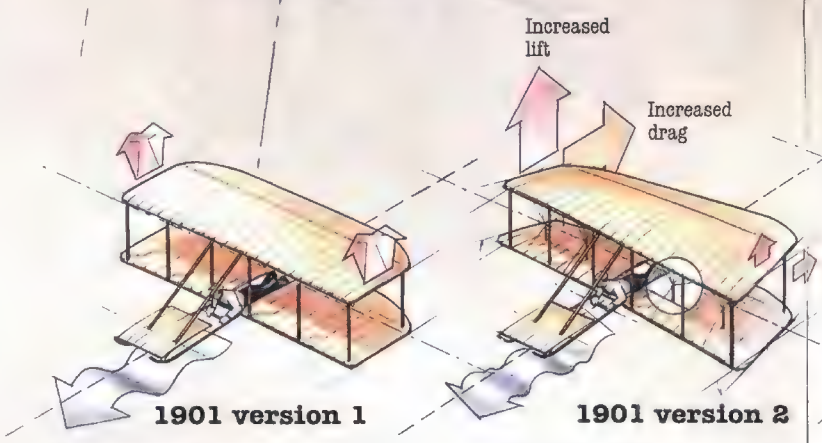
The career of the first full-scale Wright aircraft lasted less than two weeks, from October 5 to 18. It was apparent from the outset that the wings developed far less lift than the calculations based on the Lilienthal tables had predicted. After one or two tries, the notion of tethering the kite to a tower was abandoned.

Since prevailing winds were almost never strong enough to lift the weight of a pilot, virtually all of the 1900 tests were conducted with the machine flown as an empty kite, or carrying a load of sand or chain. The brothers turned the situation to their advantage, measuring the actual performance of their glider and setting the stage for the creation of accurate aerodynamic tables.

They attached a grocer's scale to the kite line to measure the combined lift and drag force on the kite. They used an anemometer to record wind speed and measured the angle of the line to the horizontal with a clinometer. With that information, they calculated that their wings were generating only two-thirds the lift predicted by Lilienthal's table. They offered Tom Tate, the young son of one of their local helpers, some thrilling rides and thereby calculated the drag of an upright body. And they demonstrated the effectiveness of their control system with separate lines running to an operator on the ground.

To attempt some free glides, they moved to the nearest elevation, some small dunes known locally as the Kill Devil Hills, about four miles south of Kitty Hawk. Having lugged the glider part of the way up the slope of the tallest (100-foot) hill, they found the wind gusting to 25 mph. "As we had...no experience at all in gliding," Wilbur wrote, "we deemed it unsafe to attempt to leave the ground."

The next day was calmer and Wilbur made a dozen free glides totalling less than two minutes. The day produced one other pleasant surprise: They had planned for the pilot to run along the ground for takeoff, assume a prone flying position between the two halves of the lower wing, then land on his feet. They discovered, however, that two men could launch the glider, and that the



1901 version 1

PROBLEM 1: Glider noses down
CAUSE: Center of gravity is forward of center of lift
FIX: Pilot moves aft

PROBLEM 2: Uncontrollable in pitch, crashes
CAUSE: Ribs flex, changing airfoil shape
FIX: Add middle spar and bracing so airfoil holds shape in modified version

1901 version 2

PROBLEM: "Well-digging"—stall-spin induced by operating wing warping for roll control
CAUSE: Adverse yaw—increased drag on wing with greater angle of attack, followed by stall on the same wing and spin in direction of stalled wing
FIX: Add double vertical surfaces (fixed tail) at rear of next version

1902

PROBLEM: At low speeds and higher bank angles, glider slips toward low-wing side
CAUSE: Wind pressure on low-wing side of fixed tail increases adverse yaw and makes matters worse
FIX: Change to single vertical rudder (movable) connected to wing warping roll-control system to correct for adverse yaw
This final configuration contains all the essential elements of modern three-axis aircraft controls.

1901-02 Wind Tunnel

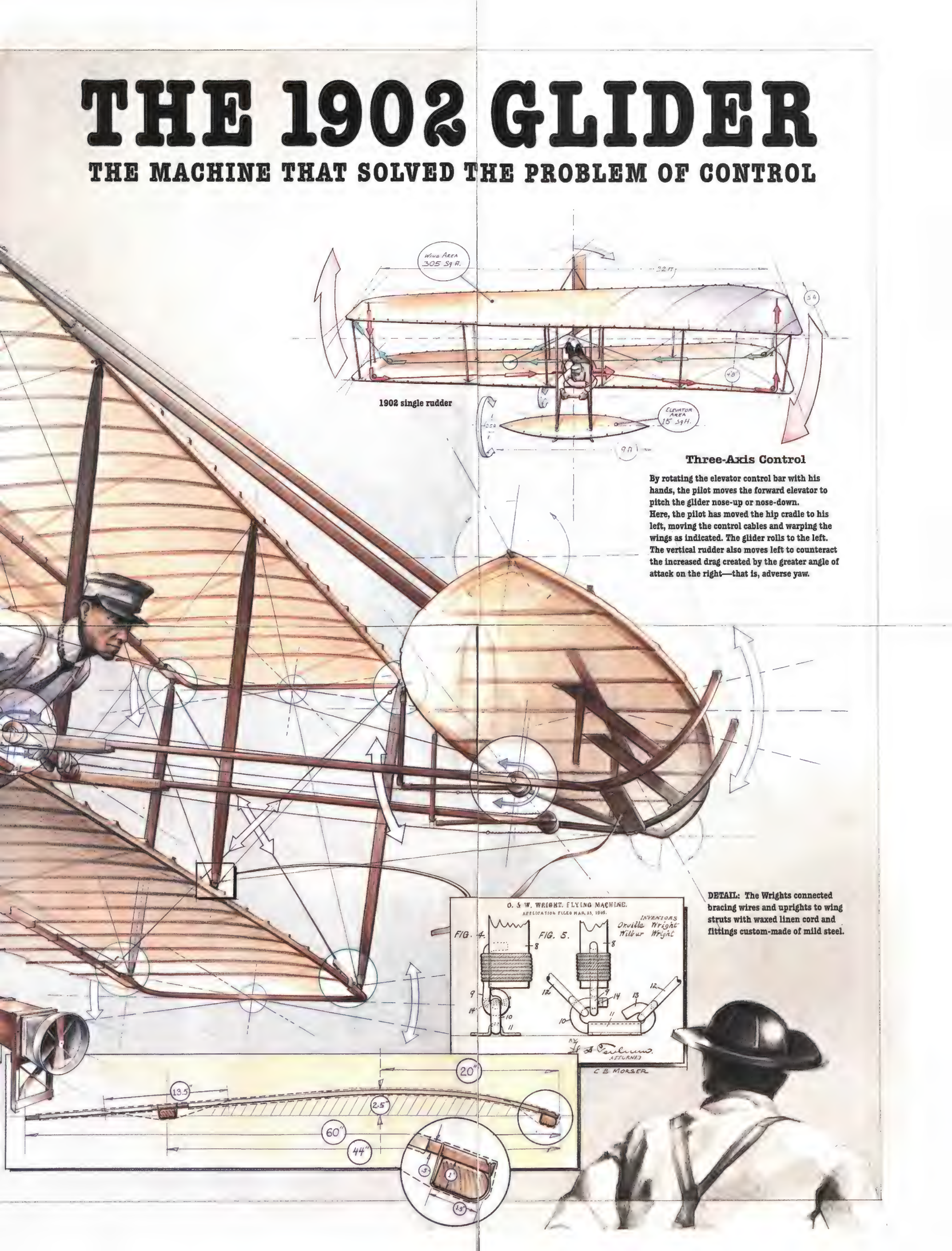
The 1900 and 1901 gliders were based on data obtained from Otto Lilienthal, which proved inadequate. The 1902 glider was based on the first accurate empirical data from tests in this wind tunnel. With it, the Wrights gathered data measuring lift and drag, as well as the effects of airfoil shape, wing shape, and aerodynamic forces at various angles of attack.

AIR&SPACE

Illustration by Bruce Morser/Design by Phil Jordan and Gretchen Maxwell/Consultant: Rick Young/The Wright Experience™
A supplement to the April/May 1998 issue of Air & Space/Smithsonian

THE 1902 GLIDER

THE MACHINE THAT SOLVED THE PROBLEM OF CONTROL



1902 single rudder

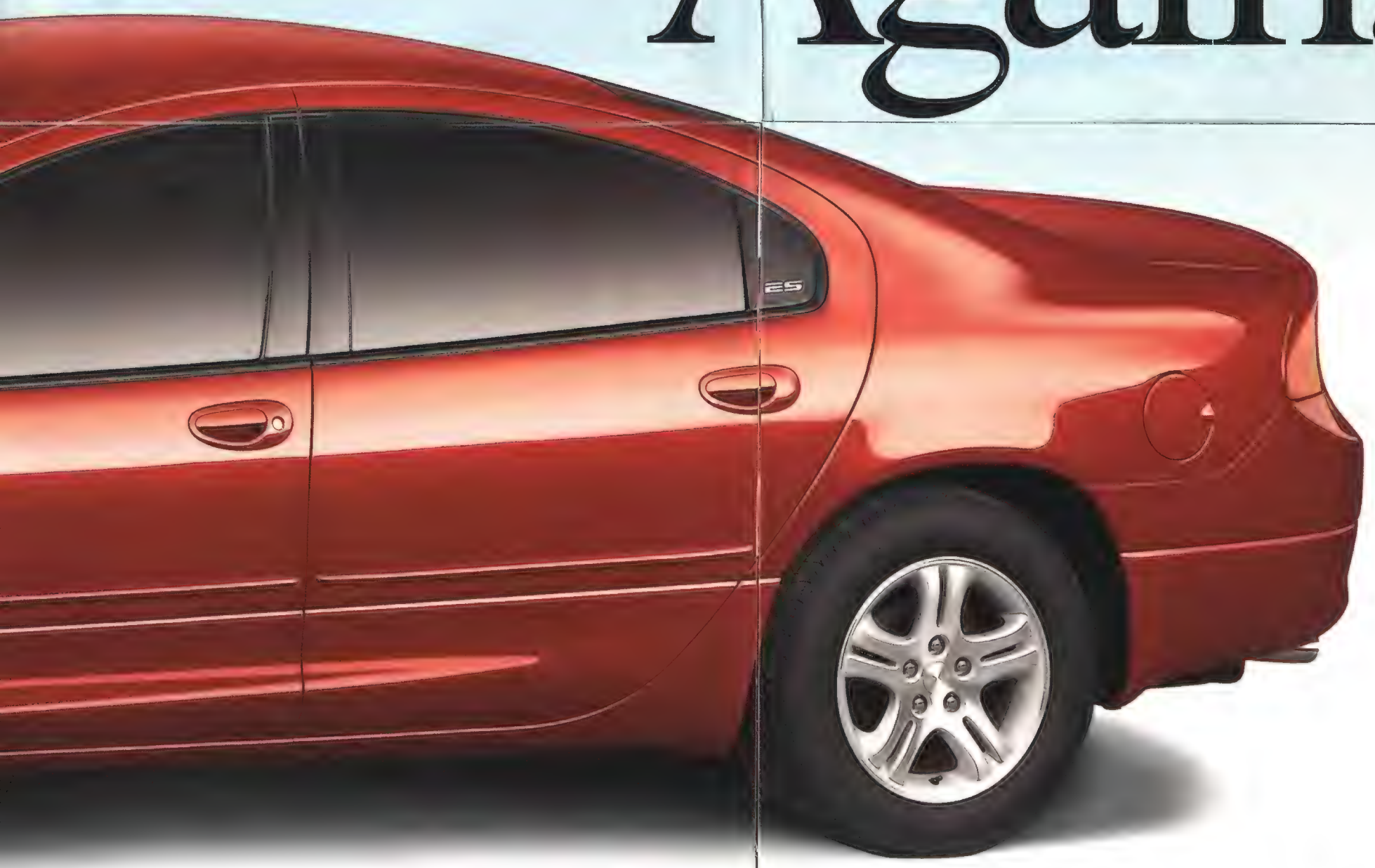
Three-Axis Control

By rotating the elevator control bar with his hands, the pilot moves the forward elevator to pitch the glider nose-up or nose-down. Here, the pilot has moved the hip cradle to his left, moving the control cables and warping the wings as indicated. The glider rolls to the left. The vertical rudder also moves left to counteract the increased drag created by the greater angle of attack on the right—that is, adverse yaw.

DETAIL: The Wrights connected bracing wires and uprights to wing struts with waxed linen cord and fittings custom-made of mild steel.

This change

s everything.
Again.



Intrepid The New Dodge

1-800-4-A-DODGE or www.4adodge.com

[1]™Orville and Wilbur Wright licensed by the Roger Richman Agency, Inc., Beverly Hills, CA

pilot had no trouble landing while prone.

At the end of the day they returned to Kitty Hawk alone, having abandoned the machine that first carried them into the sky on the spot where it made its last landing. Mrs. Addie Tate, postmistress of Kitty Hawk and the brothers' hostess on the Outer Banks, asked them for the fabric to make dresses for her two daughters. The skeleton of the machine remained at the base of the Kill Devil Hills for some months, finally disappearing in a July 1901 gale.

The 1900 Wright kite/glider is the least documented of the three vehicles. There are no contemporary drawings of either of the first two machines. Worse, in the entire collection of Wright photos, there are only three images of the 1900 machine. The brothers took a picture of Tom Tate proudly displaying a large drum fish with the glider in the background, but they neglected to photograph the details of the glider during assembly, the tower from which they flew it, or any of the free flights.

Fortunately, one surviving photo shows the glider being flown as a kite. An image of the sad remains of the craft following an accident on October 10 also proved to be very useful.

Young's finished glider weighs 65 pounds, 15 more than the original. Instead of lightweight pine he used tougher, heavier fir and substituted muslin of the sort used on all later Wright aircraft. The trussing cables and even the fittings, while closely patterned after what can be seen in the digitized photographs, are nevertheless heavier than those in the original.

Based on the Wrights' experience, Young never had much chance of achieving significant glides in the 1900 version, and even Jay was too heavy to be kited aloft. Like the Wright brothers, Young and his crew gathered performance data with a scale to measure the total force exerted on the aircraft. The results seemed to match the performance of the 1900 glider under similar conditions.

In the interest of safety, and in view of the complete absence of information on how the Wrights operated the warping system, the glider was rigidly trussed. The elevator was tested using a "dunking line," as the Wrights called it, leading from the elevator to a handler on the ground. As the Wrights reported, it was very effective.

1901: "When the time came to design our new machine for 1901," Wilbur wrote, "we decided to make it exactly like the previous machine in theory and method of operation." To improve upon the lift of the 1900 aircraft they used a less porous muslin wing covering, increased the

The 1900 glider (above) was intended to fly as a man-carrying kite but never developed as much lift as calculations had predicted. Using a grocer's scale to measure the forces on lines attached to the kite, the Wrights—and Young—obtained better data.

Jay Grattan, Rick Young's daughter, piloted the 1901 replica and discovered that the craft was difficult to balance. As Wilbur had been forced to do, she had to move back to keep the craft from nosing in. The reason: wing ribs built too thin and flexible to hold the airfoil's shape.

curvature of the airfoil to match that on which the Lilienthal table had been based, and enlarged the wing area from 165 square feet to 290. It would be the largest glider ever flown. Operating from a new shed at the base of the Kill Devil Hills, the Wrights made 50 to 100 free glides and kite tests between July 27 and August 17, 1901.

Problems were apparent from the outset. On Wilbur's first attempt to glide, the machine nosed sharply into the sand after flying only a few yards. After a series of trials in which the pilot kept moving farther to the rear, he was finally able to complete "an undulating flight" of a little more than 300 feet. "It was apparent," Wilbur admitted, "that something was radically wrong."

The cause of the problem was the relatively thin ribs, which spanned almost five feet between the spars and were so flexible that they would bend at the midpoint. The airfoil changed shape, allowing the center of pressure to shift to the rear of the center of gravity and caused the aircraft to nose into the ground. The brothers devised a complex fix, trussing down the ribs of both the upper and lower wings. When testing resumed, the elevator proved far more effective. Flights in excess of 350 feet and lasting as long as 17 seconds were the order of the day.

As the flights grew longer, however, it was apparent that the new craft, like its predecessor, developed much less lift than had been predicted. Moreover, the brothers now encountered a new and quite unexpected problem with the lateral control system. In wing warping, the pilot increases the angle of attack on one end of the wing and decreases the angle on the opposite end. As flights grew longer, it became apparent that the wing on which the angle of attack was being increased would lose speed and drop, rather than rise. It was the first step in a frightening sequence of events that led to the aircraft spinning into the sand. "Well-digging," the Wrights called it.

The brothers left the 1901 glider packed away in the shed when they returned to Dayton. Back in camp the following year, they hauled the old machine outside so they could repair the damage done to the building by winter storms and straighten things up. Suddenly, a gust lifted the old glider into the air for the last time. "Machine raised off ground and came bouncing over & over towards the camp," Orville noted in his diary that evening. "Was stopped after going about 150 ft. and breaking one upper spar." The Wrights salvaged the uprights for use with the 1902 glider and abandoned the rest of the machine.

"The boys walked in unexpectedly on Thursday," their sister Katharine wrote to their father on August 26, 1901. "[They] haven't had much to say about flying." Small wonder. But if their second glider had been something of a disappointment, it had also taught them a great deal about the movement of the center of pressure and underscored the need for a wing structure that would not deform under flight loads. It further confirmed that there was a problem with the data used to calculate performance and also revealed a dangerous flaw in the control system.

In order to demonstrate the way in which the Wrights discovered problems with aircraft design that enabled them to move forward, Young decided to build the original version of the 1901 glider. The Wright collection of glass plate photographs contains nine images of the glider, none of which show the aircraft as it was originally

constructed. Since the modifications are obvious, however, Young had no trouble reproducing an aircraft that had not been captured by the camera—in fact, a machine that no one has seen since 1901. In the interest of simplicity and safety, and because it would have no technical impact, he substituted the hip cradle wing warping control of the 1902 glider for the foot control actually employed on the 1901 glider.

Jay, who made the first tethered flights with the machine, discovered that, like Wilbur, she had to move well back of what would seem to be a natural flying position in order to keep the 1901 machine balanced. Young's early glides with the machine were also a replay of Wilbur's experience, complete with a landing hard enough to damage the structure.

With some worrisome flight test experience under their belts, the cause of the problem was as apparent to The Wright Experience team as it had been to Wilbur and Orville. As the aircraft sits flat on the ground headed into the wind with no flight load, the ribs deflect as much as an inch and a half at the midpoint between the spars. You can send a distorting wave moving the length of the wing simply by tapping your hand on top of one wingtip. It is one of those perfect cases in which the "Nova" crew can film the problems that beset the airplane in the air, then provide viewers with a close look at the cause: those flexible ribs.

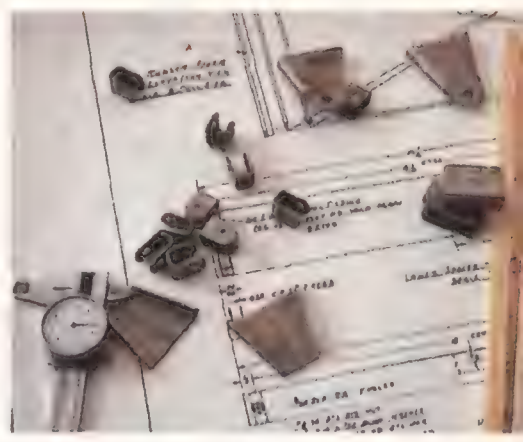
1902: The 1902 Wright glider was the product of two years of flight testing and a few weeks of priceless wind tunnel data gathered in the back room of a bicycle shop in Dayton, Ohio. The machine had recognizably different proportions than its predecessors. It was also the first Wright glider to sport a rudder.

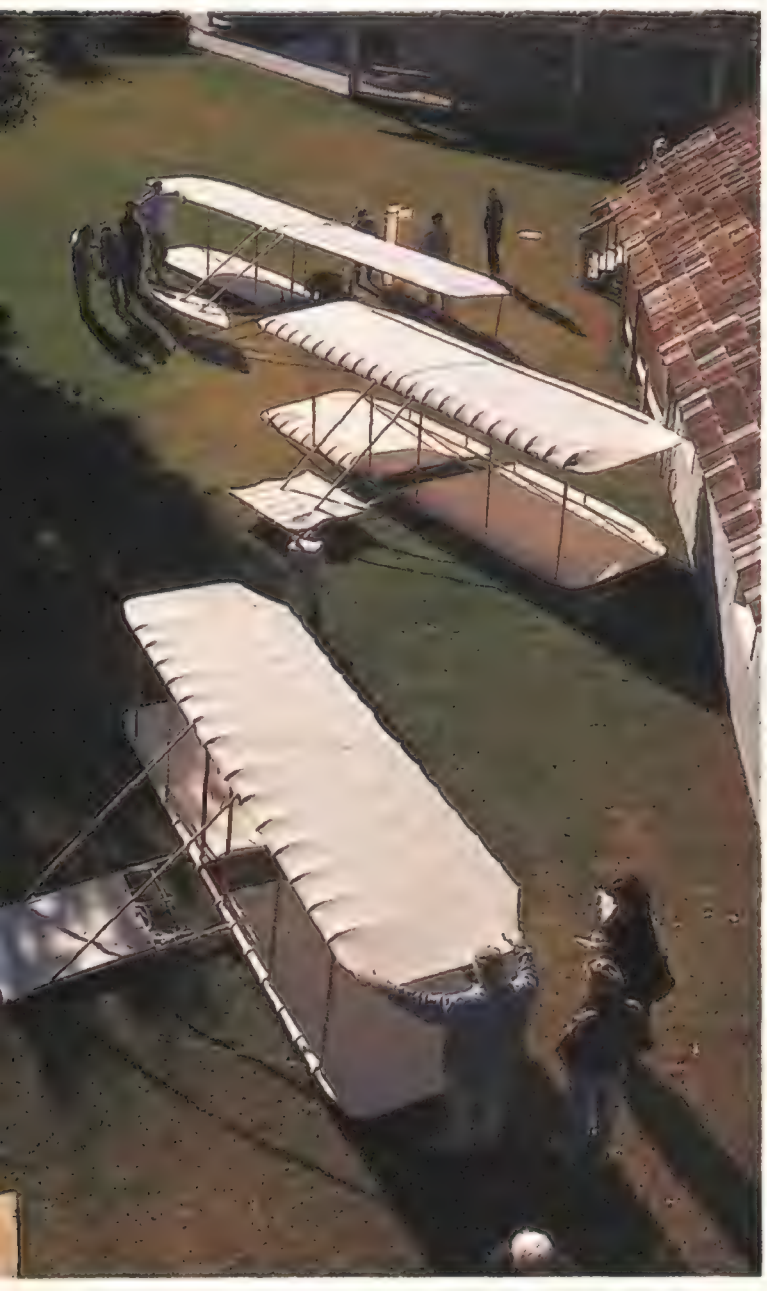
Determined to calculate performance accurately, the Wrights designed and built a wind tunnel and a pair of brilliantly contrived aerodynamic balances, then gathered the data with which to prepare their own tables of lift and drag coefficients. During the fall and winter of 1901, the tunnel also enabled them to study the most efficient proportions for a wing, the impact of varying wingtip shapes on performance, and the ideal gap between the wings of a biplane.

The Wrights recognized that the "well-digging" problem was the result of adverse yaw, an increase in drag that caused a positively warped wing to "fall behind," as they put it, rather than rise. They reasoned that a fixed vertical rudder at the rear of the craft would counteract the adverse yaw and keep the aircraft moving straight ahead. Once in camp, however, they recognized that the rudder would be even more effective if linked to the wing warping system, so as to automatically turn in the appropriate direction. The final rudder configuration—twin vanes linked to move with the wing-warping system—was installed on the glider for the 1903 season.

The Wrights completed 700 to 1,000 glides with the new machine during the 1902 season (September 19 to October 24). They made an additional 175 to 235 flights between September 28 and November 7, 1903, while they were assembling and testing the first powered airplane. The record distance for both seasons was something in excess of 610 feet. Their best time in the air, achieved on October 26, 1903, was 1 minute, 11.8 seconds.

When they left for Dayton in December 1903, the Wright brothers packed the 1902 glider away in the rafters of the hangar at the Kill Devil Hills. When they returned to their





From front to rear, the 1900, 1901, and 1902 gliders as replicated by Rick Young (left). Differences in size and proportions are easiest to see when all three pose together. Sunlight angling across the lower wing of the 1902 glider (top) illuminates the airfoil's shape. Parts and tools on Young's work table reflect his quest for accuracy (above).

camp in the spring of 1908, they found that the building had collapsed. The remnants of one of the most significant aircraft in the history of flight were poking up through the sand.

The 1902 glider was much better documented than any of its predecessors. The brothers took a great many photographs of the machine both in the air and on the ground. Octave Chanute published dimensional drawings of the glider in a French aeronautical journal in the summer of 1903. In addition, Orville Wright prepared drawings on which to base a replica of the glider that was constructed in 1934.

Though there have been a few replicas of the 1902 glider over the years, Rick Young's is the most accurate and the only one that has carried a pilot aloft. Originally constructed in 1980, the glider has appeared in so many films over the past 17 years that it qualifies as a historic object in its own right. It has been refurbished, recovered, and rebuilt so often that virtually nothing remains of the original.

It was originally constructed with the single-vane rudder linked to the wing warping system, representing the aircraft as flown during most of the 1902 tests. When flown for the WGBH film crew last year, Young substituted the twin-vane rudder installed in 1903.

Young's glider has had a much longer career than the original, but it has not come close to matching the Wright brothers' record for either distance or time in the air. That is almost certainly because Young's glider has been flown only at Jockey's Ridge, where the best slopes for long glides can seldom be used because of the wind direction. The Kill Devil Hills, although not as tall as Jockey's Ridge, offered longer slopes facing into the wind. There is every indication that under similar conditions, Young's glider would fly as far and remain aloft as long as the original.

Substantial problems remained as the brothers developed a practical flying machine during the years 1903 to 1905, but the core of their achievement was in place with the end of the 1902 glider trials. Had Wilbur and Orville Wright stopped at that point, they would still have to be regarded as the most significant figures in the story of the airplane's development. The Wrights had one failing: They did not preserve the historic craft that brought them to the brink of the invention of the airplane. Rick Young has brought the gliders, and the process of invention, back to life for us.

Filming during the summer of 1997 for an upcoming "Nova" episode drew the attention of the local populace. While it is not the first film for a Young replica, much hard-earned knowledge will be making its debut.

Travel with the Smithsonian

The Odyssey of Flight: The Battle of Britain and Farnborough Air Show

September 3-14, 1998

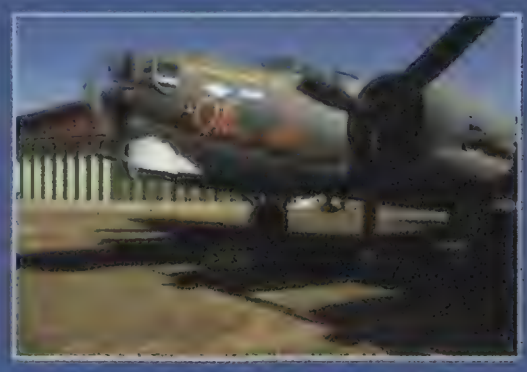
Britain's aviation history comes alive on this extraordinary tour to Britain in the company of Retired Air Vice Marshal Ron Dick.

Air Vice Marshal
Ron Dick

In the dark days of 1940 and 1941, Spitfires and Hurricanes gallantly fought the Nazi attack force in the skies over England. Winston Churchill proclaimed, "We shall fight on the beaches, we shall fight on the landing grounds, we shall fight in the hills; we shall never give up."

This classic program is designed for the true military aviation enthusiast. You'll dine aboard the HMS *Belfast*, a World War II cruiser anchored in the Thames, tour an RAF base and meet an accomplished fighter pilot. By special permission, you'll see the actual operating rooms of the Battle of Britain and spend a day at Farnborough Air Show, where you'll see the newest developments in aviation technology. Meet some of the most gallant military figures of World War II during this program.

Study Leader Ron Dick has logged 5,000 hours in the sky aboard 60 types of aircraft, from performing in aerobatics displays at Duxford to stints as a flight commander in Cyprus. He also flew a restored B17G aircraft from California to England for the RAF Museum.



Examine historic aircraft
firsthand

SMITHSONIAN
STUDY TOURS

Call Smithsonian Study Tours at
(202) 357-4700 for more information!
Visit us on the web at http://www.si.edu/tsa/sst

CODE: ASAD

LES WILKINSON COLLECTION

FALLEN ARROW

Canada's Mach 2, delta-wing interceptor was a hot airplane, a technological marvel, and destined to fail.

by Andrew Chaikin

In its broad outline, the story sounds like a fairy tale: Many years ago, in a not-so-far-away land, there was a beautiful airplane that could fly like no other of its kind. But before the airplane could prove itself to the world, its life was cut short. And ever since, the people who helped build it, those who saw its stunning white shape in the sky, and many more who heard its story have kept it alive in their hearts as a symbol of their land's lost chance for greatness.

Though it may sound like a fairy tale, the airplane is real. It flew, in Canada, for a brief period in the 1950s. Today, four decades after its first flight, it has become an object of cult worship. How good it was, why it was canceled, and the impact of its demise on Canada are the subject of an ongoing, emotional debate. It has been celebrated and criticized in books, documentaries, and even stage and television dramas. Yet few outside Canada have ever heard of the Avro Arrow.

The story begins in 1953, during the cold war. The Soviets had the Bomb, and soon, Western analysts predicted, they would have supersonic bombers. In a nuclear strike against the United States, the bombers would come speeding over the pole and across the Canadian arctic. Faced with this threat, the Royal Canadian Air Force saw itself as North America's first line of defense.

Planners at the RCAF envisioned a two-seat supersonic airplane capable of intercepting and shooting down the attackers before they reached populated areas in southern Canada. Their vision, largely shaped by the nation's distinctive geography, translated into a set of requirements so demanding that no existing airplane could meet them. Canada's vast northern expanse had few and widely separated air defense bases and a climate ranging from temperate to arctic. The proposed interceptor would have to cover a lot of ground quickly, night or day, in any weather. The RCAF determined that the aircraft would need a range of nearly 700 miles, including a fuel-gobbling five minutes of flight at Mach 1.5. And it was to have a top speed of Mach 2, a mark that had been

The Avro CF-105 Arrow was the first supersonic airplane—and the last—to be designed and built in Canada. There, its 1959 cancellation is still the subject of debate.

achieved only by an experimental U.S. rocket plane, the Douglas D-558-II Skyrocket.

In 1953 the project would have taxed the abilities of the top aircraft companies in the United States. The fact that it was being proposed in Canada, whose aviation industry was tiny in comparison, seems astonishing even in retrospect. But the conclusion of World War II had fired an extraordinary period of national confidence in Canada. Having helped to win the war, Canada "had arrived on the international stage," says historian Russell Isinger of the University of Saskatchewan. "There was an attitude in postwar Canada that there was nothing this country couldn't do, if we set our mind to it."

Canada was beginning to compete in the world market. Its largest aircraft manufacturer, A.V. Roe Canada (a subsidiary of a British aviation company), had established itself as an innovator with a jet transport called the C-102 Jetliner, which took to the air in 1949 only two weeks after the world's first jet transport, Britain's de Havilland Comet. And unlike the Comet, two of which crashed in early 1954 as a result of metal fatigue, the Canadian transport was problem-free. "Our massive but under-populated good neighbor to the north has a mechanical product that licks anything of ours," reported one New York newspaper after the Jetliner made a round-trip test flight from Toronto to New York in 1950. "Uncle Sam has no monopoly on genius." Indeed, with the Jetliner, the age of jet transport could have begun years before the debut of the airplane that gets credit for starting it, the Boeing 707. But the Korean War had begun and the Canadian government directed A.V. Roe Canada to stop mass production of the Jetliner and start producing a subsonic, all-weather interceptor, the CF-100 Canuck.

The Avro Arrow, designated the CF-105, was to be the Canuck's supersonic successor. By 1954, engineers at A.V. Roe Canada's aircraft division, newly incorporated as Avro Aircraft, were well into its design. Jim Floyd, Avro's vice president of engineering, led the effort. Floyd was an Englishman who had also been the chief engineer on the Jetliner and the CF-100. John Hodge, another émigré from England, was in his early 20s when the project began and calls it "a young engineer's dream." Hodge, who would go on to design the Arrow's engine intakes, recalls the atmosphere at Avro then as one of "absolute enthusiasm. The wives were always complaining, 'You guys think of nothing but work all the time.' That's exactly the way it was—but I think that's fairly normal when you're...breaking the barrier of one kind or another. We were doing something that hadn't been done before."

Of course, Floyd's team was not alone in that quest. In the 1950s *higher*, *farther*, and *faster* were the buzzwords of aviation, and engineers were obsessed with solving the problems of supersonic flight. "In the '50s everybody thought we had to keep creeping up the Mach scale," says Bill Gunston, a British historian of aviation.

Early in that decade in the United States, an aerodynamicist at the National Advisory Committee for Aeronautics' Langley Research Center, Richard T. Whitcomb, discovered a way of shaping an aircraft's fuselage to better enable it to achieve supersonic speeds. The intuitive approach was to give the fuselage the streamlined shape of a bullet. But Whitcomb discovered that this ideal streamlined shape needed to be applied not just to the fuselage but to the total cross-sectional area of the fuselage, wings, and tail—a principle that came to be known as the Area Rule. Area ruling gave the fuselage of a U.S. delta-wing interceptor prototype, the YF-102A, a Coke-bottle shape—and enabled it, in December 1954, to go supersonic.

At the Avro plant at Toronto's Malton Airport, Floyd's team, including aerodynamicist Jim Chamberlain, took advantage of the NACA work when they chose delta wings and an area-ruled, tail-less fuselage for the CF-105. They also made use of other innovations to improve the airplane's supersonic performance. One was to add an extension to the wings' leading edges, as the

Optimism prevailed at the Arrow's October 4, 1957 rollout. One reporter attending proclaimed it "the biggest, most powerful, most expensive and potentially the fastest fighter that the world has yet seen."

DEPARTMENT OF NATIONAL DEFENCE/COURTESY PALMIRO CAMPAGNA

LES WILKINSON COLLECTION (2)

NACA had done on at least two airplanes, including a Grumman F9F-9; another was to notch the leading edges, which had been tried by England's Royal Aeronautical Establishment. To increase the efficiency of the engine intakes, John Hodge picked the most applicable features from intake data derived from about a dozen U.S. X-planes. He says the CF-105 design effort was characterized less by invention than by a willingness to try available cutting-edge solutions.

When he talks about the challenges of building the CF-105 Jim Floyd zeros in on one particular RCAF requirement: the need for the interceptor to turn tightly enough while flying at Mach 1.5 and 50,000 feet to sustain a force of 2 Gs without losing speed or altitude—a situation it might encounter in a run-in with a Soviet bomber. "Almost any airplane can pull 2 Gs in a turn; that's nothing special at all," Floyd explains. "But to pull it at 50,000 feet at Mach 1.5 and not lose any speed or any altitude is almost an impossible job." For example, the supersonic interceptor ultimately developed from the YF-102A, the F-106 Delta Dart—which entered service in 1959 and is widely considered the best operational interceptor ever built—could pull less than 1.3 Gs at that speed and altitude. The difficulty stemmed from the fact that when an airplane turns it loses energy, resulting in a loss of speed, altitude, or both. This effect is greatly magnified in the thin air at high altitudes.

To meet the requirement, the CF-105 would need to have extraordinarily powerful engines. Originally, the RCAF had intended to purchase an existing engine, but when none was found they turned to Orenda Engines (later a division of A.V. Roe Canada), which was already working on something called the PS13 Iroquois.

Bill Gunston has called the Iroquois "the most advanced airbreathing engine of its day." Extensive use of titanium, which was still relatively new in engines, caused development headaches (in the words of one aircraft manufacturer, "it broke tools and spirits") but afforded both strength and lightness and gave the Iroquois remarkable performance for its size. For testing, one of the engines was mounted near the tail of a B-47 bomber on loan from the U.S. Air Force. When the Iroquois was run at 100 percent thrust, it was so powerful that the pilots could reduce the bomber's six engines to idle. On the CF-105, two Iroquois would provide 52,000 pounds of thrust on after-

A CF-105 awaits the installation of its delta wings and, later, its engines (above). The first five Arrows would use Pratt & Whitney J75s, but a new engine, the PS13 Iroquois, was the ultimate intent of Avro's top engineers (right; project leader Jim Floyd is second from left).

burner. (For comparison, the single General Electric J79-GE-3 engine that powered the F-104 Starfighter, a U.S. interceptor of the mid-1950s capable of sustaining Mach 2, produced 14,800 pounds of thrust on afterburner.) Two Iroquois would give the airplane (at reduced weights) an overall thrust-to-weight ratio of nearly 1:1, meaning that the thrust equalled the weight of the aircraft. Floyd's team believed this would enable the CF-105 to meet its 2-G turn requirement. But it would not be an early milestone; for safety's sake, the first five CF-105s would fly with Pratt & Whitney J75 engines, which were heavier and less powerful but at least proven performers.

Meanwhile, Avro had to contend with the RCAF's demand that the interceptor be put into service as soon as possible. This required a move that was not only expensive but risky: Instead of hand-building a prototype and using it to iron out design flaws before going into production, the company would go directly to production tooling. Floyd's team hedged its bets with what he calls one of the most extensive aircraft testing programs undertaken at that time. "We had 4,000 wind tunnel hours," he says, "and I would say at least that [amount] in testing of equipment, fuel system, electrical system, and so on."

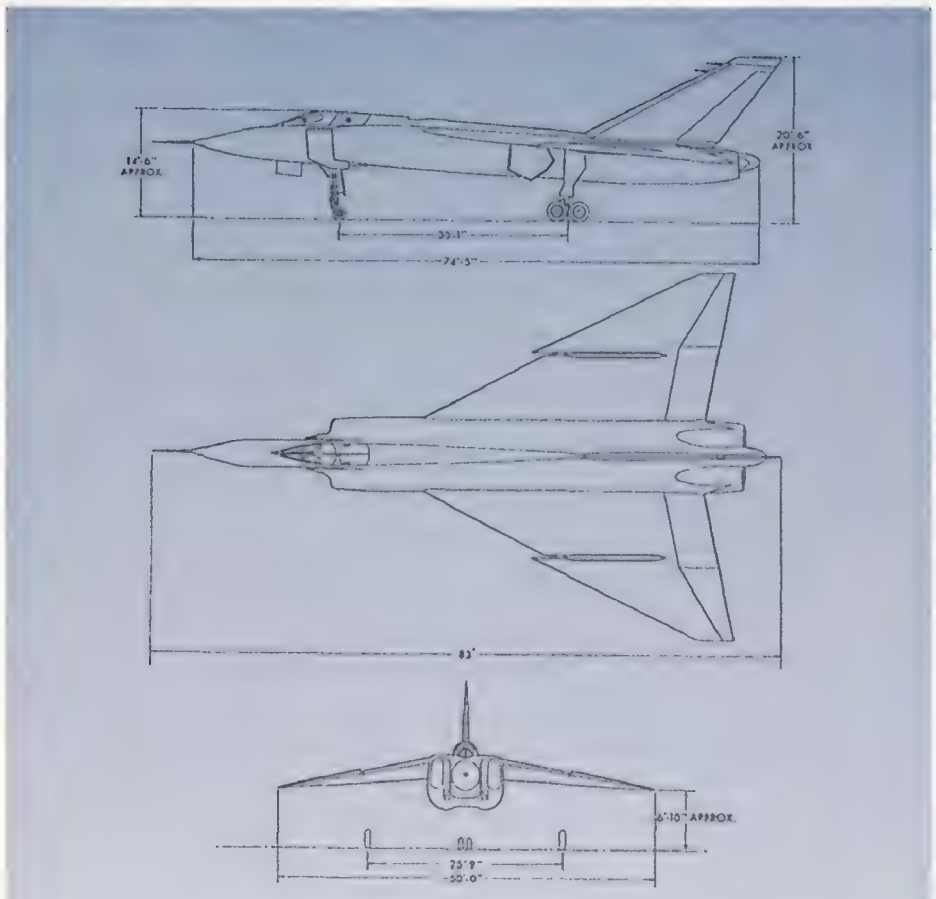
One major component, the weapons system, couldn't be tested—it wasn't ready. Faced with RCAF indecision over how to arm the interceptor, Floyd's team had designed a removable weapons pack that could be outfitted with a variety of armament. To eliminate drag it would be housed in the interceptor's belly, in a weapons bay roughly the size of that in a B-29. When the RCAF finally decided what to put in the bay, it ignored Avro's request for an off-the-shelf system and instead decided to develop its own components: the Sparrow II missile—originally a U.S. Navy project that Canada took over after it was cancelled—and a state-of-the-art weapons control system called ASTRA I, which was designed to steer an aircraft to its targets automatically, deploy the missiles, and bring the airplane home. By taking on their development, the RCAF added two projects to the program's already mammoth technical burden. Sparrow II, for example, contained an active radar system that would make it one of the most sophisticated air-to-air missiles yet envisioned. "We had never developed anything like that," Russell Isinger says. "We were really going into uncharted territory."

The ground crew at Avro readies an Arrow for flight. Orange paint had been added to aid flight test observations and make the aircraft easier to locate should it crash in snow.

LES WILKINSON COLLECTION

Still, the path looked clear at Malton on October 4, 1957, when the first CF-105 was rolled out before an audience of VIPs, Avro employees, and reporters. With a 50-foot wingspan and a fully loaded weight of 31 tons, the Arrow dwarfed its contemporaries. A writer for the British journal *Flight* described the scene as a giant curtain was parted: "Through the opening came a lowly tractor; and behind it appeared the biggest, most powerful, most expensive and potentially the fastest fighter that the world has yet seen—the CF-105 Arrow."

A list of the Arrow's innovations, which went well beyond its aerodynamics, engines, and weapons, seemed to back up such exorbitant appraisal: For control, there was a fly-by-wire system that electronically transmitted the pilot's stick movements to the control surfaces—one of the first used in an operational aircraft. Its actuators, the part of the hydraulic system that translates fluid pressure into movement, were powered by hydraulic pumps with an operating pressure of 4,000 pounds per square inch—all but unheard of at the time. Even the main landing gear were a design *tour de force*: To fit into the thin delta wings they retracted like contortionists, rotating and shortening by eight and a half inches. Avro engineers spoke confidently about reaching speeds beyond Mach 2 and an altitude of 70,000 feet. Flying Mach .92 at sea level, they said, the aircraft would be able to go straight up. "Even the U.S.A. has nothing like the Arrow," *Flight*



LES WILKINSON COLLECTION

CF-105 Avro Arrow

Canada's big supersonic interceptor accommodated a pilot and a weapons control officer. The five Arrows that flew contained no armament; all Arrows were intended to eventually carry six Falcon guided missiles—the replacement for the canceled Sparrow II missiles.

exulted. In the States, *Aviation Week* was only slightly more restrained; its cover story on the rollout said that the Arrow "has given Canada a serious contender for the top military aircraft of the next several years." It was a remarkable reception—especially since the Arrow had yet to fly.

Even as these accolades were being written, however, the Arrow's future was in doubt. For several years the burgeoning cost of the program had troubled its supporters in Canada's Liberal government. Speaking in the House of Commons in 1955, minister of defense production C.D. Howe said of the Arrow, "We have embarked on a program of development that frankly gives me the shudders." Then, in June 1957, an election shattered the Liberals' 22-year reign and Conservative John Diefenbaker—a prairie native who promised more money for social programs and for Canada's farmers—became prime minister. Now he and his minority government inherited the single most expensive defense project in the country's history. Pressed by the RCAF for a commitment to put the Arrow into production, Diefenbaker and his ministers put off the decision until the following fiscal year.

But the Arrow's survival was becoming more than a matter of cost. The United States and the Soviet Union were engaged in a race to build intercontinental ballistic missiles, and some influential observers, including British minister of defense Duncan Sandys, were saying that ICBMs would soon replace bombers as the greatest cold war threat. Ironically, the world awakened to the reality of this potential threat the very day of the Arrow's rollout, when the Soviets used an ICBM to launch Sputnik. At the same time, U-2 spyplane flights were revealing that the Soviet bomber threat had been greatly overestimated. Suddenly, the question being asked was not only whether Canada could afford the Arrow but whether the aircraft would be obsolete by the time it entered service.

At Avro, Floyd's team paid little attention to the storm clouds on their horizon; they were busy readying the first Arrow, number 201, for its test flights. When the moment of truth arrived, on March, 25, 1958, the Arrow team's confidence in the airplane appeared justified. The airplane proved airworthy and remarkably problem-free. Floyd discovered how much so when Avro test pilot Jan Zurakowski turned in his post-flight list of problems, known as the snag sheet. "That snag sheet was the most amazing thing I've ever seen," Floyd says. "There were only three items on it. I've seen prototypes that have gone up for the first time and there were 13 pages of things that had to be put right." Subsequent flights turned up a few bugs, such as in the fly-by-wire system. But on the whole the Arrow's systems—with the exception of the Sparrow II missiles and ASTRA I weapons control system, which were still in development—performed as well as or better than designed.

But could the interceptor meet the RCAF specs? The question would have to wait until flights by the sixth Arrow, number 206, which would be the first equipped with Iroquois engines. For the time being, the flights of the big white delta-wing aircraft over the Toronto area were already generating public excitement. One Arrow engineer told an interviewer a decade later, "You go home at night and people want to hear about it.... It was something they could look at and say, 'Hey, that's what we did in this country.' "

COURTESY JAN ZURAKOWSKI

To the Conservative government in Ottawa, however, the Arrow was anything but inspiring. John Diefenbaker was a man who, in the words of one government official, "hoped that postponements might beget miracles." But by the fall of 1958, as the one-year deferral neared its end and the Conservatives returned to the Arrow question, the situation had only worsened. The economic boom Canada had enjoyed at

Avro employees jubilantly greeted test pilot Jan Zurakowski after the Arrow's first flight; only 11 months later, they were shocked by the program's cancellation.

At the time of the cancellation, two Arrows inside the Avro plant were nearing completion; both were destroyed (left), as were all finished Arrows on the flightline (below). Supporters were aghast that such an extraordinary aircraft (opposite) was to be sold for scrap.

the time of the Arrow's inception had given way to recession and rising unemployment. To a government looking for ways to cut deficits and finance social programs, the Arrow was an obvious target. It was also political quicksand: Canceling the project would mean endangering thousands of jobs at Avro and its subcontractors, of which there were more than 650 across Canada. Up to now, the Canadian Army and Navy had gone along with the RCAF's assertion that it needed the Arrow, providing the consensus that was essential for any big defense program in Canada to continue. But the consensus was breaking down. Shrinking military budgets made it impossible for the other services to accept the huge share of the pie being consumed by the interceptor. If the RCAF wanted the Arrow, it would have to justify it.

For Air Marshal Hugh Campbell, that was becoming increasingly difficult. In 1952 the RCAF had forecast a need for 500 to 600 CF-105s; now the number was down to 100 or 150, largely because of the diminished perception of the Soviet bomber threat. Furthermore, during a visit to the United States in August, Canadian officials had been unsuccessful in their effort to sell the Arrow to the U.S. Air Force, frustrating hopes that foreign sales might help defray the Arrow's cost. Instead, on the same trip, they received a pitch for the BOMARC, an anti-aircraft missile Boeing was building. Campbell let it be known that even with the BOMARC his wish list still included the Arrow—but the reality was, there wasn't enough money for both. Reluctantly, he informed Minister of National Defence George Pearkes that although he could not recommend canceling the Arrow, he would accept the measure if the government promised to pay for an alternate supersonic interceptor.

Now it was up to Diefenbaker's cabinet to act. Through September, the members met several times. Once again they deferred, opting only to cancel the expensive Sparrow/ASTRA weapons system in favor of a cheaper, off-the-shelf alternative. With winter coming on, they extended the Arrow program for another six months in what one Cabinet member would later call "the most expensive unemployment relief measure in Canadian history." Diefenbaker announced that BOMARC missile bases would be installed in Canada and promised a reappraisal of the Arrow in the spring.

Some in the Canadian press sensed what Diefenbaker could not yet say: The Arrow was doomed. The editor of the popular weekly *Macleans*, long critical of the project, wrote an essay entitled "What led Canada to junk the Arrow?" in which he declared that "the manned aircraft is as dead as the muzzle-loading musket." Avro president Crawford Gordon later responded with his own essay: "We should and will go on building Arrows." Jim Floyd's team at Avro interpreted the government's request to find an alternative weapons system as a vote of confidence. Says historian Isinger, "They saw what they wanted to see."

Meanwhile, on November 11, 1958, Avro test pilot Spud Potocki put Arrow number 202 into a climb above 50,000 feet and accelerated to Mach 1.98. At that point, says Fred Matthews, who supervised flight test engineering at Avro, the test conductors halted the run. The program's emphasis was still on checking systems rather than pushing the performance envelope. "When we cut him off, he was still accelerating and still climbing," Matthews recalls. "We never did find out how fast [the Arrow] would go, even with the

J75s." Still, the interceptor had nearly reached its target for maximum speed, and in the process it demonstrated extraordinary performance. Floyd and his team felt certain that Arrow number 206, the first to fly with Iroquois engines, would not only meet the RCAF specs but exceed them. Unofficially, they planned to use 206 to steal the world speed and altitude records set in the spring of 1958 by the YF-104A. They never got the chance.

On the morning of February 20, 1959, the day known to Arrow veterans as Black Friday, John Diefenbaker addressed the House of Commons in what he called "a somewhat lengthy statement on the subject of one facet of national defense of Canada.... The government has carefully examined and re-examined the probable need for the Arrow aircraft and Iroquois engine known as the CF-105.... The conclusion arrived at is that the development of the Arrow aircraft and Iroquois engine should be terminated now." He went on to praise the new airplane and its engine but added, "Unfortunately, these outstanding achievements have been overtaken by events." Diefenbaker blamed the cancellation on the changing assessment of the Soviet threat. His use of a military argument infuriated the RCAF. But Isinger says the real reason for the cancellation—that Canadians *couldn't* do

LES WILKINSON COLLECTION (3)

anything they chose because they couldn't afford to—would have been far more dangerous politically. "Psychologically," Isinger says, Diefenbaker "wasn't prepared to stand up and say [that]. He just couldn't do it."

The news reached Avro employees early in the afternoon. "We were all busy doing our jobs," John Hodge recalls. "The PA system came on and said 'The government's canceled the contract. We have to cease all work. Go home. Don't call us, we'll call you.' " Arrow number 206 had been only two weeks away from its first flight. Now, in one blow, 14,000 workers at Avro and Orenda, including most of Floyd's 1,500 engineers, were unemployed; so were thousands more who worked for contractors. Over 20,000 people—a quarter of Canada's aerospace workforce—lost their jobs.

In the days and weeks that followed, many Arrow veterans found jobs in the United States. Some of them, including John Hodge, were hired by the newly created NASA for a program that would prove even more challenging: sending astronauts into space and, eventually, to the moon. Jim Floyd went back to England, where he applied his Arrow experience to design studies of the Concorde supersonic transport.

Their aircraft at Avro were not so fortunate. As the Arrow team dispersed, the six completed Arrows were cut into pieces and sold for scrap. A newsman flew overhead and snapped pictures, which Arrow engineer Rod Rose later saw. "It's sickening," he recalls. "Like looking at a morgue."

Today the Arrow is very much alive, not only in the memories of those who worked on it but among a new generation of enthusiasts and authors. One is Greig Stewart, who grew up in the Avro neighborhood. "My friends' fathers worked on [the Arrow]," he says. "I saw it every day—from the first flight on." Stewart's 1988 book, *Shutting Down the*

National Dream, chronicled the rise and fall of Avro Aircraft, which folded in 1962. Stewart wrote it, he says, "not because I'm an Arrow buff but because I wanted to know what went on down the street from me." The interviews he conducted with Avro employees often ended with them in tears.

Stewart soon learned of the Arrow's hold on the Canadian psyche. "Here I thought I was just writing a story of a plane and a love story," he says. "I didn't realize what a cult impact it has." To understand what Stewart is talking about, you need only to peruse the Internet. One Web site promises to satisfy "Terminal Avro Arrow Obsession Syndrome," with everything from original stories and poems to cartoons (for the addresses of this and other Arrow-related Web sites, see Credits and Further Reading, p. 82). In online discussion groups, devotees debate the facts behind the Arrow's demise and its impact. "I believe the Arrow was scrapped to stop Canadians from believing in themselves," wrote one participant. "The cancellation of the Arrow program may be the single most defining moment in Canadian history," wrote another, adding that if the CF-105 had kept flying successfully "Canada would be the aerospace leader today and the Americans would [have been] answering to us." These sentiments reveal that the story of the Arrow touches on the Canadian sense of national identity.

The same passion was behind a 1997 Canadian Broadcasting Corporation mini-series, "The Arrow," which had a cast headed by Dan Aykroyd as Crawford Gordon. The movie, which included both real and fictional characters and events, gave voice to two of the enduring myths about the Arrow: that John Diefenbaker ordered the destruction of the Arrows out of spite and, most seductive of all, that one of the airplanes escaped destruction and remains hidden in a barn somewhere in the Canadian countryside. Neither claim is true, says Greig Stewart. He calls the Arrow "Canada's first conspiracy theory," but he recognizes that it's hard to dispel myths.

That's a phenomenon Russell Isinger has experienced himself. "I had more or less accepted the myth of the Arrow—this wonderfully sophisticated plane shot down by a visionless government that didn't have the courage or intelligence to see it through," he says. "But I found out the exact opposite." Noting that decisions were made early on that allowed the project's costs to balloon out of control, he says, "The project was doomed practically from the beginning. The cancellation was inevitable."

U.S. Air Force historian Richard Hallion agrees. "It's more than just money," he points out. "It's mission supportability: The number of people you're going to need to maintain this thing, the operational readiness rate, the problems you're going to have with all these complex systems—complex hydraulics, complex electronics, the fly-by-wire, complex engines.

"You think: What would the future have been if the Royal Canadian Air Force had a bunch of CF-105s?" Hallion says. "And I don't know.... But my feeling is, if history is any guide, that this airplane would have buried them in red ink until they got this thing operational.

"For me," he adds, "the bottom line on the Arrow is simply this: Aviation history is replete with examples of technologically fine, evocative aircraft that were canceled for one reason or another." Witness, he says, the U.S. YF-12 inter-

LES WILKINSON COLLECTION

Arrow 205 had flown just once before the program's end (above); Arrow 206—the would-be record-breaker with the Iroquois engines—never flew. In their stead, Canada purchased the Boeing-built BOMARC missile (opposite).

COURTESY WILLIAM ZUK

DEPARTMENT OF NATIONAL DEFENCE

ceptor, a cousin of the SR-71 spyplane, and Britain's TSR-2: both highly sophisticated aircraft that never entered service because the world changed before they were ready.

To Isinger, the most troubling claim made by Arrow veterans, writers, and enthusiasts is that the United States sought to kill the program by pressuring Canada to buy BOMARC missiles, knowing the country couldn't afford both. The rumor was fueled in part by Canada's purchase of 66 surplus F-101 Voodoos from the United States shortly after the Arrow program collapsed. "There's not a shred of believable evidence," Isinger says. "Quite the contrary. [The Americans] were always supportive." In fact, Isinger points out, months before the cancellation, the United States had offered to buy Arrows for the RCAF to fly in their North America Aerospace Defense Command squadrons. (The Canadians declined, in part because the offer wouldn't have saved the troubled project.) The United States also offered to donate the Arrow's weapons control system, which would have allowed Avro to offer the Diefenbaker government a deal on 100 airplanes for $3.5 million each. The Americans declined to buy the Arrow for themselves, Isinger says, for the same reasons Canada started its own aviation industry: They had their own specialized requirements and their own aircraft companies to protect. Still, the theory survives, he says, because Canada harbors a certain apprehension about its neighbor to the south. "At the back of every Canadian's mind," Isinger adds wryly, "is a sort of ancestral idea that you're going to annex us."

The nose section of Arrow 206—the one Jim Floyd's team had hoped would break records—is today displayed in Canada's National Aviation Museum in Ottawa, along with an Iroquois engine and two delta-shaped wingtips.

Bill Gunston has called the Arrow "in almost every way the most advanced of all the fighters of the 1950s...as impressive and successful as any airplane in history." Today, citing the Arrow's intended speed and range, he says, "If I had to defend Canada against manned aircraft attack, I still can't think of anything flying today that I would prefer.... If I was a Russian bomber, I'd have been scared stiff."

But Tom Alison, military aviation curator at the National Air and Space Museum, points out that the Arrow never fired a missile. "If you can't shoot the weapon, then all you are is a spectator," he says. "If you say, 'Anybody who hasn't actually done that shut up and sit down,' they're going to have to shut up and sit down. Having said that," the former SR-71 pilot adds, "I wish I'd had a chance to fly it." Of course, the Arrow/Iroquois combination that wins the highest praise never flew. "It's a paper airplane," says Richard Hallion. "And paper airplanes are always wonderful."

Isinger wonders whether the Arrow would have been so romanticized had it continued flying. "Because the Arrow failed so publicly and so spectacularly, everybody can remember it the way they want to remember it," he says. "I think its reputation is going to be preserved a lot longer because it didn't succeed than if it had been built. And," he adds, "if it hadn't been so damn beautiful."

For program manager Jim Floyd, who eventually returned to Canada, the Arrow remains a source of mixed feelings. He maintains that even now, four decades later, no airplane has matched it. "There are faster airplanes, like the SR-71; there are very maneuverable planes. But I can't think of one single airplane today that would meet that RCAF specification." Floyd, who was besieged for interviews after the CBC film aired, has been surprised and somewhat dismayed to see the Arrow receive so much publicity so long after it ceased to exist. "I'd like to see the Arrow story buried with the dignity that the people who worked on it deserve," he says. It was appropriate when one RCAF cadet squadron renamed itself after the plane, Floyd says; "I thought, this is a very good, fitting epitaph to the Arrow." Bill Gunston offers another: "It's one of the greatest of the might-have-beens." ✈

COURTESY WILLIAM ZUK

The Arrow has been the object of a resurgence of interest in Canada lately, partially fueled by a 1997 TV movie (left). The only known remains of the aircraft—portions of 206—are in an Ottawa museum (right). The artifacts were more recently added to an exhibit of Canada's aviation achievements.

THE OUTER

Planetesimals, plutinos, centaurs, Kuiper Belt Objects—astronomers scouring the fringes of the solar system are finding all sorts of hangers-on.

Ten telescopes sit atop the 13,796-foot dormant volcano Mauna Kea on the island of Hawaii, and to get to them, there is only one road you can take. From a distance it looks unremarkable, but a close encounter shows how deceptive appearances can be. The steep grade—500 vertical feet for every mile—ruins transmissions, and the washboard surface wears out shock absorbers and rattles hoods until they pop loose. Users of the Mauna Kea observatories trade disaster stories like baseball cards: the $900 tow to sea level, the three Japanese researchers who bailed out of their truck just before it hurtled off a switchback, the local family killed when their brakes overheated and failed.

Dave Jewitt, a University of Hawaii astronomer, guns a Chevy Suburban up the road, apparently heedless of the cautionary tales. With the radio blasting heavy metal rock, he races through the otherworldly Moon Valley, where Apollo astronauts practiced driving the lunar rover, past red cinder cones from volcanic eruptions. Jewitt is anxious to get to the University of Hawaii's 2.2-meter-diameter instrument.

In 15 minutes he reaches the top of the volcano. He fiddles with a key and bounds up a spiral staircase to the telescope office. There he begins preparations for a night of observing.

Since 1987, Jewitt and his research partner, Jane Luu of the Harvard-Smithsonian Center for Astrophysics, have been working on a telescopic survey of the far reaches of the solar system. Along with other teams around the world, the two are identifying new bodies orbiting the sun—bodies that are out far beyond what used to be considered the edge of the solar system. The discoveries may soon shed light on several longstanding astronomical mysteries, such as where comets come from and precisely how planets and solar systems form.

The first five years of their survey, Jewitt and Luu found nothing. In August 1992 they were analyzing images from the 2.2-meter (seven-foot) telescope when they noticed a spot of light that seemed to have moved against the background. Cautious, they observed the object for three more nights. It was still there, still moving. They calculated that the object was well beyond the orbit of Neptune. Measuring between

LIMITS

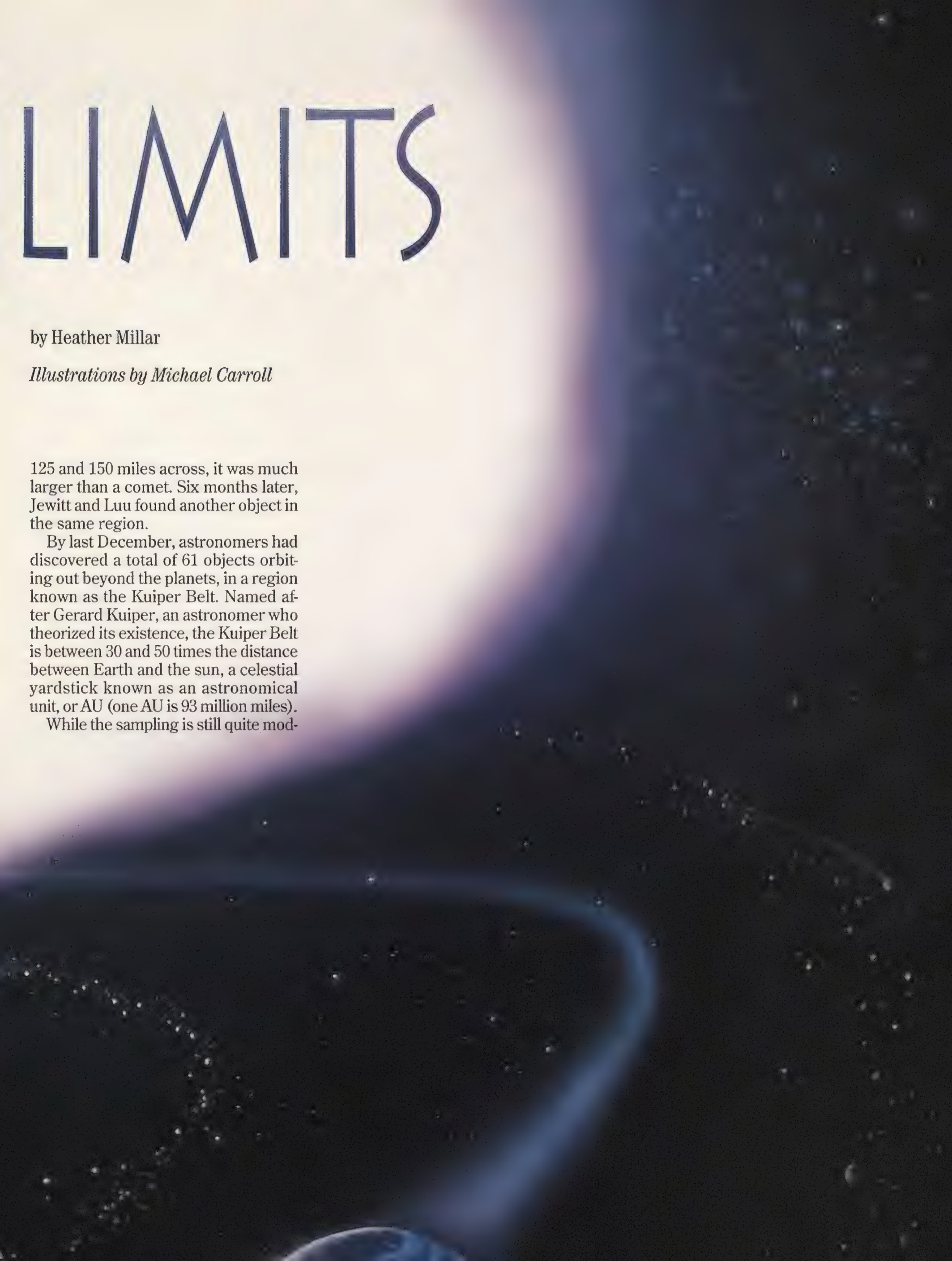
by Heather Millar

Illustrations by Michael Carroll

125 and 150 miles across, it was much larger than a comet. Six months later, Jewitt and Luu found another object in the same region.

By last December, astronomers had discovered a total of 61 objects orbiting out beyond the planets, in a region known as the Kuiper Belt. Named after Gerard Kuiper, an astronomer who theorized its existence, the Kuiper Belt is between 30 and 50 times the distance between Earth and the sun, a celestial yardstick known as an astronomical unit, or AU (one AU is 93 million miles).

While the sampling is still quite mod-



est—Jewitt and Luu estimate that as many as 70,000 similar large objects and one billion smaller objects may be out there—astronomers have already observed some interesting variations among their discoveries. Some Kuiper Belt Objects move in nearly perfect circles, while others loop deep into space on elongated—elliptical—orbits. A few, known as centaurs, circle the sun between Jupiter and Neptune and are thought to be Kuiper Belt escapees migrating toward the inner solar system. KBOs called plutinos orbit in paths similar to Pluto's, which is tilted 17 degrees from the ecliptic—the plane on which the other planets orbit. So many plutinos have been found that some scientists believe that Pluto, whose mean distance from the sun is 39.5 AU, is not a planet at all but rather a really big KBO (see "Identity Crisis," next page).

The idea that thousands of planets, mini-planets, and planetesimals might soon replace the familiar nine solar satellites is a startling one, but more important is how the discoveries could enlarge our understanding of solar system development.

Far from the sun and thus relatively untouched by heat and collisions, KBOs are probably the most primitive members of the solar system yet found. Accordingly, the study of what KBOs are made of could eventually reveal the composition of the solar system's building blocks. Since different materials reflect different colors, several teams are working to analyze the light from KBOs. "We suspect that the KBOs are mixtures of silicate rocks and ices—water, carbon monoxide, carbon dioxide—but we have no direct evidence," says Jewitt. Measurements of colors or spectra might provide that evidence.

Other information will come from observing how various-sized objects are distributed throughout the Kuiper Belt. Do some regions contain lots of Pluto-sized objects, and others a swarm of much smaller stuff? How big do the objects get? Such data could prove useful for theorists trying to envision the details of how the planets developed.

As astronomers gradually learn the extent of the Kuiper Belt, they will be able to determine if our outer solar system looks like those observed elsewhere, such as the disks of rubble that have recently been detected around nearby stars like Beta Pictoris. In addition, explains Luu, they will be able to estimate how massive the original

solar nebula was. Knowing that, and knowing how many planets exist now, they will be able to determine how efficient planet formation is. "To simplify greatly," Luu says, "if the original amount of dust and gas was enormous and now there are only nine major planets, then perhaps planet formation isn't so efficient. If, on the other hand, there was less material, perhaps planet formation is very efficient, and other solar systems are quite common."

Wearing a black shearling coat to keep warm in the telescope's air-conditioned interior and the high-altitude chill outside, Dave Jewitt moves quickly through the curved office at the 2.2-meter telescope. He slouches his long, lean frame into a black leather chair and glances at a list of viewing fields taped on a wall.

"Let's begin by locating a bright star near field 3070," he tells the telescope operator. The operator punches in a few commands. Like an enormous gyroscope, the housing rotates while the telescope inside pivots into position. Since most astronomers believe the KBOs are leftovers from planet formation, Jewitt points the telescope at a region along the solar system's ecliptic.

First Jewitt chooses a bright guide star to keep the telescope aligned, then he starts a simple computer program that directs the telescope to take a 2.5-minute exposure. When the shutter closes, a microphone in the telescope registers a clang. Then the telescope is moved and another exposure is made. By the 15th exposure, the instrument has scanned 225 million miles of sky.

The telescope returns to the first field of view and begins to take 15 more exposures of the same regions of sky. It continues until three full sets of 15 have been made.

After about two hours, Jewitt is ready. With a push of a button, he sends the first set of exposures 5,000 feet down to Hale Pohaku (Hawaiian for "House of Stone"), the astronomers' dormitory, where Luu and Chad Trujillo, Jewitt's graduate student, wait to analyze the data.

For decades, this is how we have conceived of the development of our solar system: In the beginning, there was a cloud of gas and dust, and it condensed under its own gravity to form the sun. Perhaps one percent of the matter remained as a nebulous ring that began to spin around the sun. As it did, the cloud flattened into a disk. Some of the particles stuck to each other and formed pebbles, which met and formed rocks, which met and formed bigger rocks, and so on. As the larger clumps grew, gravity pulled the components into spherical forms. The planets took shape: Heavier, metal-rich rock condensed into asteroids and the inner planets—Mercury, Venus, Mars, and Earth—while gas and light dust became the gaseous giants farther out—Jupiter, Saturn, Uranus, and Neptune. After that dramatic opening act, the theory went, things have remained roughly the same for about four billion years.

FAR BEYOND THE KUIPER BELT, WHERE THE SUN'S GRAVITY BARELY HOLDS IT, OORT'S CLOUD OF ICE AND ROCK MAY BE HOVERING.

But over the last half-century, astronomers have been suggesting there might be more to the story. In 1949, an Irish gentleman scholar named Kenneth Essex Edgeworth speculated that while there wasn't enough material beyond Pluto to form observable planets, plenty could remain in the form of bits of ice and rock too small for 1940s telescopes to see. Edgeworth wrote a paper suggesting that a flat disk of cosmic rubble could be circling the outer solar system and that this could be the origin of short-period comets—those that make a trip around the sun in less than 20 years. (Gerard Kuiper came up with the same idea two years later, but he worked at the core of American planetary astronomy, while Edgeworth was an outsider to the astronomical community, so Kuiper's paper was cited more frequently and the theoretical band became widely known in this country as the Kuiper Belt.)

The recent discoveries confirming these astronomers' theories are transforming the vision of our solar system as stable and mature into a scenario in

Identity Crisis

Somewhere, Gerard Kuiper must be smiling. The first observations of the belt of celestial matter he envisioned are causing a slew of controversies. How do you name things if you're not exactly sure what they are?

Take the case of Pluto. If it turns out to act more like a Kuiper Belt Object than the other eight planets, will it be kicked out of the planetary club? "Support for keeping Pluto a planet is already minimal," notes Dave Jewitt. And other outer objects, regardless of how large they prove to be, won't be called planets either, say most astronomers. Some have suggested alternatives: planetesimals, minor planets, Kuiper Belt planets.

That last suggestion pushes some noses out of joint. Two years before Gerard Kuiper published his theories about distant sun-orbiting objects, an Irish astronomy scholar, Kenneth Essex Edgeworth, envisioned much the same thing. "To use the name of Kuiper only is a typical expression of American provincialism," sniffs Andrea Milani, an Italian theorist. Indeed, while the term "Kuiper Belt" has currency in America, the adjective "Edgeworth-Kuiper" wins out elsewhere. To avoid offense, some astronomers have taken to using "trans-Neptunian." (That alternative also dodges yet another complication: Is the correct pronunciation "KOY-per"—the Dutch way—or "KY-per"?)

"I think we should be able to call these objects whatever we want," says Jane Luu. Inspired by John LeCarre's *The Spy Who Came in From the Cold*, she and Jewitt privately named their first Kuiper Belt discovery after the novel's protagonist: Smiley.

which a disk of material is still evolving, with objects continuing to affect one another in slow, subtle patterns.

For example, Jewitt and Luu have discovered two objects orbiting the sun in a strange place: between Jupiter and Neptune. Other teams, such as one at the University of Arizona, had spotted similar objects, called centaurs, before. The largest, Chiron, appears to have had comet-sized pieces broken off it, raising the possibility that other comets have originated this way. Another curious observation is that the centaurs orbit in huge, unstable paths—they can remain among the giant planets for only a few million years before gravity either ejects them from the solar system or shoots them into tighter orbits near the sun.

The objects called plutinos may also be vulnerable to instability. Some astronomers, studying models of the evolution of the outer solar system, have hypothesized that a few got jostled out of their orbits and ended up as moons of the outer planets—Pluto's Charon, Neptune's Triton, and two small moons recently discovered orbiting Uranus.

Then there's the mystery of how to account for 1996TL_{66}. In November 1996, Jewitt and Luu found an object whose orbit took it as far as 130 AU, way beyond the 30- to 50-AU region considered the "classic" Kuiper Belt. At 12 billion miles from the sun, 1996TL_{66} (the nomenclature is based on an obscure system for designating the time of discovery) is the farthest object ever observed in our solar system. Luu and Jewitt's team suggested that 1996TL_{66} was a scattered KBO that had been deflected into an elliptical orbit by an encounter with a larger object. Later, Hal Levison at the Southwest Research Institute in Boulder, Colorado, and Martin Duncan at the University of Toronto published a paper demonstrating that, based on a theoretical model, a natural by-product of the outer solar system's development would be scattered KBOs such as 1996TL_{66}.

In addition to expanding our celestial neighborhood, the discovery has made scientists ask: Could rubble be orbiting all the way out to the edge of the sun's gravitational field?

The possibility has been raised before. In the 1950s, a Dutchman named Jan Oort started to mull over a curious phenomenon. While short-period comets orbit in the ecliptic, long-period comets such as Halley's and Hale-Bopp swoop in from all directions. To explain this, Oort proposed that a roughly spherical array of comets must enclose the solar system like a huge dandelion puff with the sun in the center. This cloud would hover near the outer limit of the sun's gravitational pull, at about 50,000

AT 12 BILLION MILES FROM THE SUN, THE OBJECT CALLED 1996TL_{66} IS THE FARTHEST BODY EVER OBSERVED IN OUR SOLAR SYSTEM.

AU—far beyond the Kuiper Belt. Oort hypothesized that this sphere was formed when the gravitational fields of the giant planets—Jupiter, Saturn, Uranus, and Neptune—acted as slings, throwing comet-like debris from the central solar system way out to where the sun's gravity barely holds it in place.

So far, no one has yet confirmed the existence of the Oort Cloud. But the discovery of 1996TL_{66} is a step in that direction. Says Luu: "It starts us thinking: If there's stuff at 130 AU, what about at 1,000 AU?"

The small room where Luu and Chad Trujillo prepare to receive Jewitt's data has the suspenseful air of a campaign headquarters waiting for election returns. It is nearly 1 a.m. before they have enough data from the telescope to begin their analysis.

As the first set of numbers from the telescope starts to stream in over a direct T1 line, Trujillo's computer blips. A program he has developed begins lining up the stationary stars from the observing run and corrects for flaws in the telescope's charge-coupled-device receptors. The program compares the three versions of each field and looks for objects that appear to move in a constant speed and direction. When it finds a possible KBO, it circles it in red.

After another hour, the data are ready for Luu and Trujillo. They start the long process of checking the candidates put forward by the computer, using an old-fashioned technique called blinking. It works on the same principle as a flip book creating simple animation of a merry-go-round or galloping horse when you flip the pages quickly. Luu and Trujillo check the computer screen to see if each candidate moves in the appropriate way. It's like watching yellow sand blow over black pavement.

There are hundreds of images, thousands of KBO candidates, all of which need to be checked immediately. If the astronomers see a Kuiper Belt Object tonight, they can look for it tomorrow night. At least two observations are necessary for a preliminary orbit to be plotted and for the object to be recognized by the International Astronomical Union's Minor Planet Center, the organization charged with officially accepting such new discoveries. The work stretches into the early hours of stale coffee and aching backs. Still, Luu and Trujillo stare at the fluttering images.

Suddenly Luu sits up and yells "There!" She points to the upper right corner of a frame. "Do that again!"

To any lay person, it looks like a blur, a smudge. But after 10 years of blinking on Mauna Kea, Luu picks it out immediately. She and Trujillo flip through the images again. Now Trujillo sees it: a small speck that moves steadily in a straight line from frame to frame.

"Cool," he says.

They note that it's the third night and that the image is on the 70th frame. The speck gets a provisional name: 3070. If they see it again tomorrow night, the speck may be on its way to becoming a full-fledged Kuiper Belt Object.

The teams hunting for KBOs dream of bigger and better telescopes and digital sensors, more telescope time, and spacecraft that can hop from KBO to KBO. One upcoming effort that holds promise is a mission NASA is planning called Pluto Express, in which a robotic vehicle would be sent to Pluto to get

data on the geology, surface, and atmosphere of the planet and and its satellite, Charon. The recent Kuiper Belt discoveries have inspired talk of extending the mission to explore that region. First, however, Pluto Express has to get off the ground. It's slated for launch early in the next decade but has yet to be funded.

Back on Mauna Kea, Luu and Jewitt completed more than two weeks of observations. Then, in the second week of September, they returned to Cambridge, Massachusetts, where Jewitt is on sabbatical. After rechecking and reanalyzing their data, they confirmed that they had indeed found two new KBOs, still known by their internal monikers, 3070 and 5017.

On September 8, Luu e-mailed their measurements and observations to the International Astronomical Union's Minor Planet Center. Brian Marsden, director of the bureau and a Harvard colleague, plugged the information into his database. From there, it was published and sent around the world as part of the Minor Planet Electronic Circular. Marsden gave the two new objects their official names: 1997QJ_4 and 1997QH_4. And so the portrait of our ever-changing solar system was refined a little further.

MEAN MACHINE

The Soviet Union is gone, but one of its deadliest weapons lives on. Meet the Mi-24 Hind.

by William L. Smallwood

Photographs by Chad Slattery

Emerging from the shadows of Communism, Russia's Mil Mi-24 Hind has found a home with the U.S. Army at Fort Bliss near El Paso, Texas.

Right after the Gulf War ended, I interviewed an F-15E pilot. We were in one of the squadron briefing rooms at Seymour Johnson Air Force Base in North Carolina, and the pilot had been describing his wartime missions. The interview was going well; he was proud of what he and his fellow aviators had done to crush Saddam Hussein's war machine.

When he began to describe his postwar missions, however, his mood changed. During the spring of 1991, he was flying over northern Iraq, enforcing a no-fly zone mandated at the surrender table. But the victors had screwed up. The prohibition of flight included only fixed-wing aircraft. Down below him was a mountain road jammed with Kurd refugees. Iraqi Hinds—Soviet-built helicopter gunships—were circling and.... As the pilot was telling me this, his words stuck in his throat. I looked away for a moment, sensitive to his embarrassment. Then he continued, determined, it seemed, to make sure I would report what he and his backseater saw when they dove upon the scene. I listened with growing anger as he described the Hinds S-turning along the road, firing into the Kurds with machine guns and rockets. "Those damned Hinds," said the pilot.

Over the next several days the pilot's story was echoed by other F-15 aviators who had witnessed similar acts of carnage. All were angry and disgusted that their leaders would not allow them to attack the helicopters and save the Kurds' lives. *Those damned Hinds....*

We would like to think that with the Soviet Union gone the days of worrying about Hinds are over. But as the Gulf War proved, the Hind has established a life of its own—a life that we now know has outlasted the nation that created it. U.S. Army intelligence lists some 2,100 Hinds flying in 34 countries. In addition, it is quite possible that these gunships will continue to be a hot export item for Russia. So we dare not forget about the Hind.

Chief Warrant Officer Jeff Stayton, a U.S. Army pilot, understands how dangerous an adversary the Hind can be.

A veteran of two combat tours as a helicopter gunship pilot, Stayton now flies the Hind in training exercises around the country, using the Soviet helo to simulate attacks on U.S. troops. The work is challenging (high-speed flights at unforgivingly low altitudes), and it requires the 48-year-old pilot to be intimately familiar with an aircraft he never expected to fly.

Stayton was introduced to the Hind sometime during the mid-1980s (the details are still classified), when one of America's spook agencies got its hands on a Mil Mi-24 Hind and transported it to a remote airfield in the United States. At the time, Stayton was flight testing the Army's new McDonnell Douglas AH-64 Apache gunship. Then one day he was told that he was volunteering for a secret assignment.

Some days later Stayton found himself in a dimly lit hangar, staring at the Hind. "I was slack-jawed," says Stayton, "and my first thought was, *What a big mother!* They had weighed it and, empty, it weighed 21,000 pounds—that's three times heavier than a [Bell AH-1] Cobra and about one and one-half times the weight of an Apache."

Stayton spent an hour examining the outside of the Hind before he even opened the cockpit door. Stenographers followed him and recorded his observations, and he had plenty. He was impressed by the half-inch layer of steel armor that surrounded the cockpits of the gunner and pilot, and that shielded vital parts of the engines and transmission. He was also impressed with the big round windscreens in front of the two cockpits. Ballistics engineers had counted the number of glass laminates in the windscreens and calculated that they were almost as bullet-proof as the steel armor.

What really sets the Hind apart from other helicopters is the fact that it has wings. With a span comparable to that of the Lockheed F-104 Starfighter, the downward-slanting wings of the Hind, engineers had calculated, would provide up to one-fourth of its lift at cruise. (Later, after flight tests, they found that the percentage of lift varied between 22 and 28 percent, depending upon airspeed and other factors.) Stayton, who had grown up at the airport in Kerrville, Texas, helping his father and mother run a fixed-base operation, had flown fixed-wing aircraft since he was a boy, and he began to think of the Hind as a hybrid—mostly a helicopter but partly a fixed-wing aircraft. This mental preparation later saved his life.

If you are a pilot, you always want to do a walkaround. And if it is an aircraft you have never flown, you want to be meticulous, during both the walkaround and the cockpit familiarization procedure that follows. But eventually a tension begins to develop: You know that you should be methodical in all phases of preflight, but all the while you're thinking *Enough of this. Get fired up and go.*

It wasn't that easy with the Hind. Stayton had an operating manual of sorts, one that had been translated by a Russian linguist. But the Russians used even more acronyms than Americans, so much of the operating information was gibberish. Still, Stayton admits that the manual "filled in all the gaps on procedures." In addition, he had transcripts of some interviews with Soviet pilots who had flown the Hind. But these were only occasionally helpful because the spooks who had asked the questions knew nothing about flying helicopters.

"The biggest problem was the switchology," says Stayton in his soothing Texas baritone. "Since it was a single-pilot aircraft, all the systems had to be operated from the one cockpit. When you sat down in there, you were surrounded

As part of a classified program conducted some 10 years ago, U.S. Army pilot Jeff Stayton (above) taught himself to fly a captured Soviet-made Mi-24. Today the helicopter is part of a fleet of Soviet aircraft flown by the OPFOR, an opposing force of airmen (left) who teach U.S. troops how to survive enemy attack.

Flown in the former Soviet Union since 1947, the Antonov An-2 biplane makes a slow, stable platform for dropping OPFOR paratroops into the Fort Polk staging area.

with switches from your left elbow to your right elbow, and they were all labeled in Cyrillic—Russian letters that our crew chief called 'acrylic.' The engineers had figured out what some of them were and had labeled those with Dymo tape. But the function of many of them had to be discovered by trial and error."

Hindering matters further, the entire test program had to be conducted under the cover of night or during "satellite windows"—times when Soviet spy satellites were not looking down on them. During one such window, the ground crew towed the Hind outside and Stayton got it started. "That was something," he says. "It was about dusk, and when I fired up the APU [auxiliary power unit], I saw an orange light behind me and watched the crew chief's eyes turn as big as dinner plates. I guess a three- or four-foot flame shot out of [the APU vent, which sits behind the rotor]. It must have been pretty spectacular." (Stayton points out that though startling, it's nonetheless normal for the Hind's APU to belch flame during the start-up.)

Stayton taxied the Hind during the first outing. He didn't fly it until the next satellite window, and he'll never forget that flight.

"It really became quiet after the canopy was closed and sealed," he says. "That's because of the pressurization system they designed to protect the crew from chemical and biological agents—not for high-altitude flight. I had an engineer, Wayne Petrie, bless his heart, in the front seat, and we had watched [intelligence videos] of Hinds taking off in East Germany. Their pilots flew it off like an airplane, so I went down the runway just like I was in a Cessna and it flew off beautifully."

Stayton says he also drew heavily on his experience flying U.S.-manufactured helicopters, but he gives credit to the team of aeronautical engineers and test pilots with whom he was working. "I don't want to leave you with the impression that I put on a Chuck Yeager hat and went out and did this by myself," he says.

As for the risk of testing an aircraft without direct guidance from the manufacturer, Stayton recounts that he didn't focus on his own safety. "Actually, my biggest worry was being the first one to cause damage," he says. "My antennae were up for everything. You don't want to be the first one to blow it.

"I guess I also had a fear of having to use that damn parachute they made us wear," he continues. "The aircraft was in the experimental category and the Russians wore parachutes, so you will, by God, wear parachutes. But the thought of using that parachute was terrifying. You don't jump unless the thing is uncontrollable. So why would you want to step out and fall into a blender? It made no sense. Yet if I didn't jump out, they'd say, 'He got killed because he didn't use his parachute.' "

Stayton's first flight started out routinely, and he was impressed with the smooth, quiet ride. "Then, about two-thirds of the way through the flight, we're starting to lollygag around pretty good, and I began looking through the rocket sight going, 'Well, I'll just pretend I'm shooting rockets,' " he says. "I hit the switch, which in the Cobra is the rocket-fire button. Instantly, we went through three violent oscillations of every pitch, roll, and yaw moment in the aircraft. I got into a Dutch roll and into all kinds of maneuvers I wasn't used to being in. It was quite a ride." By pressing what he'd thought was the rocket-fire button, Stayton had allowed the flight control stability system to recenter, which, because of all his prior

maneuvering, resulted in a series of violent movements.

I was at Stayton's headquarters at Fort Bliss, Texas, when he was telling me about this first ride. Sitting across the table from us was another test pilot, Gordon Lester, who had also flown the Hind. "How about the angle-of-bank problem?" prompted Lester.

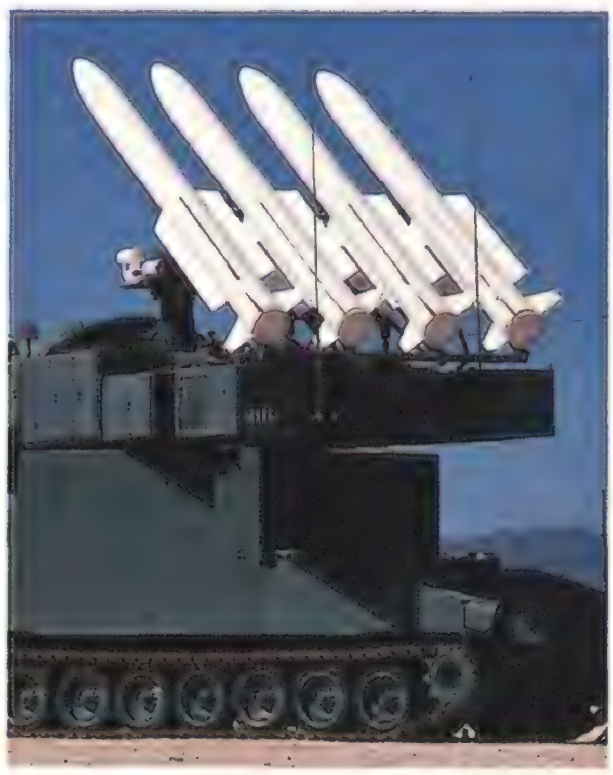
The angle-of-bank problem, Stayton explained, was caused by the Hind's wings. In a banked turn, the down wing quickly loses lift while lift is maintained on the upper wing. Thus there is a strong tendency, particularly in a slow, banked turn, for the lift on the upper wing to keep the aircraft rolling. In U.S. Army helicopters, says Stayton, he would counter the roll by pulling the cyclic control—the primary helicopter control mechanism, which is comparable to the control stick on fixed-wing airplanes—aft and in the opposite direction of the roll. But the Hind, he says, "just keeps rolling. If you try to counter the roll with the cyclic, you're going to roll over on your back and do the dying cockroach number. Luckily, when I first got into that situation, I called on my fixed-wing experience and pushed the nose forward. The increased airspeed added lift on the bottom wing, which allowed us to fly out of the maneuver. The only problem with this recovery is that you have to have altitude you can give up. Down low, the angle-of-bank problem is critical."

Stayton's flight testing days occurred at a time when the Soviet Union was a bitter enemy, and the Hind was one of the Soviets' most feared weapons. In those days it was imperative to learn everything possible about the craft. If U.S. forces had been attacked by the brutal gunships on some European battlefield, knowing how they worked could have been a crucial factor in neutralizing or defeating them.

And though the cold war is over, the knowledge that Stayton gained is still highly valued. He now works for an organization called OTSA, which stands for OPTEC Threat Support Activity. Founded in 1972, OTSA is now a division of the U.S. Army's Operational Test and Evaluation Command, which does the final testing and evaluating of equipment before it is deployed in the field. In addition to its testing role, OTSA provides a realistic threat environment in which to teach U.S. troops from all services to survive combat. What makes OTSA's training environments seem real is its use of the weapons—almost exclusively of Soviet origin—that U.S. military forces are likely to encounter on battlefields around the world.

Stayton's assignment with OTSA is limited to its aircraft. He is in charge of a fleet that includes three Hinds, two Mi-17 Hips, one Mi-2 Hoplite, one Ka-32T Helix, and three An-2 Colt biplanes, among others. His work takes him to military bases all over the country, but Stayton spends most of his time at Fort Polk in central Louisiana, which is the home of the Joint Readiness Training Center. About once a month, a light infantry brigade (or its equivalent) travels to the JRTC, and, for approximately two weeks, engages in simulated combat against the "locals," who make up a battalion-size, highly trained, and highly skilled opposing force (OPFOR)—a force that utilizes Stayton's piloting skills and OTSA's Soviet aircraft.

I went to Fort Polk last September to observe one of these infantry combat exercises. Primarily, I wanted to study the Hind close up. And although



U.S. pilots praise the roominess and quiet of the Hind's pressurized cockpit (above). Rounding out the OPFOR arsenal is the Kamov Ka-32T Helix (right), a utility transport, and the XM11S, a Soviet-made, radar-guided air defense system.

I went there with a deep dislike for the Hind and a congenital fear of any aircraft without a full set of wings, my other goal was to fly in it.

I spent several days with the Sixth Infantry soldiers (the good guys, known as the BLUEFOR, or Blue Force) and the OPFOR (the bad guys—Stayton and company), learning how they fight and kill each other. OPFOR aircraft are outfitted with blank-firing, laser-equipped weapons, including machine guns, 30-mm cannon, rockets, and anti-tank missiles. Whenever the OPFOR aircraft succeed in "hitting" the BLUEFOR troops on the ground, a high-pitched tone is emitted from a laser sensor that each soldier wears. To add detail to the simulation, each BLUEFOR member carries a casualty card, and when he has been hit, he opens the envelope to find out if he has been killed or wounded. (I was not hit, but I peeked in my envelope; I would have had a nonfatal wound in the right shoulder.)

The BLUEFOR infantrymen are given blank-firing, laser-equipped weapons of their own, and each OPFOR aircraft is equipped with a laser receiver. It's possible that the lowliest BLUEFOR private carrying an M-16 rifle could bring down one of the aircraft with a lucky shot. Much more likely, however, would be a kill by a shoulder-fired

Stinger surface-to-air missile or one of the Stinger batteries; their laser beams are proportionally much more powerful than the laser beam emanating from an M-16. If one of the laser receivers on an OPFOR aircraft is hit, indicator lights mounted inside and outside the aircraft begin flashing, signalling the aircrew and those on the ground that the aircraft has been destroyed.

While at Fort Polk, I pestered tired soldiers in the field during their breaks with school-teacherish questions. To Sergeant Willie Sims, an anti-aircraft missile system team chief, I barked, "Quick, you hear a helicopter coming in low. How can you tell it's a Hind?" There was no hesitation: "Sir! Double bubble canopy! Slanted wings! Large weapon racks! Side windows bulging! Special sound, not like one of our helicopters!" The Sixth Infantry Division had trained for this exercise for nearly two years, and aircraft recognition studies, which help prevent friendly fire tragedies, had clearly been a major subject in the curriculum.

Then I began to learn about the Hind. Like Stayton, when I first saw it, I was impressed with its size. But after walk-arounds with Stayton and the crew chiefs, I became impressed with some of its other characteristics. Previously, I had thought of it as just a gunship. But behind the two cockpits is a cargo space big enough to carry eight fully equipped combat troops.

The wings are also impressive. It is easy to see how they could furnish about one-fourth of the lift. But it had to be

OPFOR pilot Steve Davidson (above) uses the Hind (below) in mock attacks on infantrymen training at Fort Polk. At his disposal is a variety of blank-firing, laser-equipped weapons carried under the helicopter's wings, including rockets and AT-2 anti-tank missiles.

The BLUEFOR troops try to down the Hinds with surface-to-air missiles, either launched from the Avenger system (above) or shoulder-fired (below).

pointed out to me that this design feature allows the nearly 57-foot-diameter main rotor to be dedicated largely to forward propulsion, enabling the Hind to be one of the fastest helicopters in the world, with a top speed of 210 mph. A bonus of such a design is that the long wings host an array of hardpoints, where rocket pods, air-to-air missiles, and even bombs can be carried.

I learned the machine has its weaknesses, or "design tradeoffs," as my hosts, who are great admirers of the Hind, put it. Most astonishing to me is that it doesn't hover like any respectable helicopter. Part of the problem is the main rotor being designed primarily for forward propulsion. The other problem is that the big wings break up the rotor draft, which in turn destroys a major chunk of its ground effect. Stayton and his colleagues point out that prolonged hovering was not part of the Hind's original mission, and that some hovering is possible. But they also add that it is not permitted more than a cumulative six minutes over the life of the engines.

The Hind is not an agile machine, having what the OPFOR pilots call a "limited maneuver capability." This means that the Hind cannot fly nap-of-the-earth, one of the basic modes of combat flying employed by U.S. helicopters. Nap-of-the-earth attacks require pilots to fly up to a masking barrier such as a grove of trees, stop, hover, pop up, fire on the enemy, and then drop down again into a hover. The only way the Hind can come close to this tactic is to fly low and use its camouflage to mask its approach against something like a ridge, then rise, fire, and take advantage of its high speed to get away.

The Hind's speed figures prominently in the tactic that Stayton uses for the attacks on the ground troops at Fort Polk, where the terrain is lushly wooded and fairly flat, though elevation differences of 50 to 100 feet are not uncommon due to low-lying creek beds and bayous. "If you're flying 200 feet above the ground, you pretty much can be seen from anywhere in the maneuver area," says Stayton. "So you gotta stay down in the dirt."

At a distance of several miles from the target, which can be any combination of troops standing out in the open, a Humvee equipped with surface-to-air missiles, trucks, or light-armor vehicles, Stayton and his gunner, who rides in the Hind's front seat, approach at an altitude of 30 to 50 feet above the highest obstacle in their flight path. At a distance of two miles, they drop down to 10 to 30 feet above the highest obstacle, which means they may be flying lower than the trees on either side.

Depending on the terrain and the target, Stayton's attack airspeeds range from 100 to 160 mph, and the ideal distance for him and his weapons officer to start firing is 2,700 yards from the target, although they could be as close as 1,100 yards. After discharging their weapons, Stayton and his front-seater get clear of the ground fire area, and, if necessary, they make another run on the target. If a soldier on the ground manages to launch a Stinger missile, Stayton can attempt to break the missile's infrared lock by flying a zigzag pattern in order to put trees, hills, or even another aircraft between his helicopter and the oncoming missile.

In the beginning of the two-week training period at Fort Polk, the ground troops are usually unable to defend themselves against the Hinds' onslaughts, but by the end they have gotten proficient at blowing the craft out of the sky. Camping out in the field for several days, they are often running on little or no sleep, which slows down their ability to react. And though they may have trained against U.S. helicopters at their home bases, they've never seen anything as fast as the Hind. "The way this thing screams as it comes low—it does not attack the way a U.S. helicopter attacks," marvels Reginald Fontenot, OTSA's director. "All of a sudden it's right there—boom! The guys afterward say it's amazing how scared [they were]. They actually thought they were at war."

While I was hanging around the OTSA

ramp learning about the Hind, the rest of the Soviet fleet was engaged in the battle that was raging some 20 miles to the east. The Mi-17 Hip was flying resupply missions, the Mi-2 Hoplite was flitting about the battlefield making observations, and the lumbering An-2 Colt biplane was busy delivering OPFOR paratroops.

Finally it was my turn to fly. Though I was not allowed to ride aboard the Hind during a training exercise, I still got to see what it could do. Stayton was already in the pilot's cockpit—grinning—as I pulled on my borrowed helmet and the crew chief guided my feet into the front cockpit, where the gunner sits. I immediately had a sense of spaciousness as I settled into the almost luxurious leather seat. I had already studied the instruments while standing outside. Now, as Stayton engaged the APU starter and the machine began coming to life, I started thinking as a pilot. Let's see, where is the attitude indicator, the airspeed indicator, the altimeter? Everything was off to my left, but that was okay; even though the front-seater had rudimentary flight instruments and controls, the thought of juggling input on rudder pedals, collective, and cyclic made me glad I didn't have to think about flying.

Through the intercom I heard Stayton going through his checklists. Soon the blades of the main rotor were a blur and the crew chief was sealing me in. As Stayton applied power to the twin 2,190-horsepower Klimov TV3-117 turboshaft engines we started to taxi, and I began to appreciate what he had told me about the pressurized cockpits. It was amazingly quiet—even when we got to the runway and applied takeoff power.

The visibility from the gunner's seat is incredible. You feel almost as if you are sitting in a glass bowl suspended in front of the aircraft. That is the good news. The bad news is that flying just above the pine trees at 165 mph, it looks like you are flying through the trees rather than over them.

Stayton is a skillful pilot. I judge that not from the fact that we stayed out of the pine trees but from the silky way he moved the aircraft through turns, climbs, and dives. Some pilots have the gift; Stayton is one of them.

We were out almost an hour, and our rocket attacks were simulated in an area away from the main battle (the Hind would soon be flown in a serious engagement, and it was imperative not to be observed ahead of time). That was all right with me. With Stayton pointing out potential targets and calling out ranges for rocket deployment, the flight was actually becoming enjoyable. As we cruised through the trees on the way home, I started wishing the gunner's seat had an ordinary stick so I could perform some of the maneuvers.

The Hind is quiet, smooth, powerful, and fast. And in conversations after the flight, Stayton and fellow Army pilot Steve Davidson made more admiring comments.

"It's tractor-tough."

"Put it in a barn for a year, then charge up its batteries and you can fly away in it. You can't do that with our helicopters."

"It rides smooth, just like an old '62 Cadillac."

"Carry along a common-tip screwdriver, a roll of safety wire, and a grease gun and you can fly it for a hundred hours."

Finally, Stayton gave what seemed to be the ultimate accolade. One day during a conversation, he leaned back and said, "You know, if I wanted to just fly a helicopter for the fun of it, there is no question that the Hind would be far and away my top choice."

I can understand that. Without question, the Hind is an outstanding aircraft. It is also superbly designed for the job it is supposed to do. But I cannot get those Kurds out of my mind. For me, the Hind is still a mean machine.

Coming in fast and low, the Hind is the indisputable star of the war games at Fort Polk. "The way this thing screams as it comes low—it does not attack the way a U.S. helicopter attacks," says program director Reginald Fontenot.

COMMENTARY:

The New Prospectors

Line up the launch vehicles, the space rush is about to start. A swelling cadre of entrepreneurs worldwide is preparing to aggressively challenge international treaty and customary law on an issue key to humanity's expansion into space: the private ownership of natural extraterrestrial resources.

The idea of staking a claim to, say, an asteroid, as at least one U.S. company intends to do eventually, may seem bold, far-fetched, or just plain silly, depending on whom you ask. But such efforts are filling an important role by transforming debates about the role of the private sector in space from academic musings to confrontational realities. Forcing this issue will ultimately enable a more rapid off-Earth migration of humankind.

Governments can provoke, initiate, and regulate economic development but they can't sustain it. Nowhere has this been clearer than in the past 30 years of government-supported space exploration and its tentative forays into the exploitation and development of space resources. True, the government-built and -backed space shuttle, the forthcoming international space station, and the dilapidated Mir have their compelling moments. But for the kind of broad-scale, long-haul commitment essential to develop space resources and sustain human space migration in significant numbers, we will have to rely on private commercial activities—and on the risk-taking entrepreneurs and masses of small-change investors who back them. And the fundamental principle underlying their activities is the private ownership of property.

Members of the space commerce and business communities have been straining at the entrepreneurial bit for a long time to gain direct access to space and the resources beyond Earth orbit. But doing so means first challenging the pronouncements of national governments for the right to work in space. These entrepreneurs are now beginning to assert persuasively, on a grassroots level, the final directive of an old adage: lead, follow, or get the hell out of the way.

Although no major ratified space treaty addresses private property rights in space, those that do exist are hardly encouraging to private enterprise there. The principal treaty governing space activities is the *United Nations Outer Space Treaty of 1967*. The United States and the Soviet Union were the main negotiators and signatories of the treaty, and in many respects it reflects an attempt by those two nations to control each other's political, economic, and military capabilities and objectives in space.

The treaty purports to establish some ground rules for space exploration. Among them, it prohibits one nation or group of nations from asserting national sovereignty in space, over Earth's moon, or over any other natural celestial body. Thereby, it eliminates, among other possible activities, the right of a nation to hold the space equivalent of land rushes for its citizens—a method of property distribution that has promoted settlement of frontier areas in the past. It also holds all national governments accountable for their citizens' activities in space, private commercial activities included. And it establishes the principles that all nations have the right to access space and that all space activities, commercial and otherwise, are to be carried out peacefully and for the benefit of all mankind.

The treaty does not directly address the issue of ownership of natural resources in space—whether by governments, private corporations, or individuals. Its only reference is by implication, and that is to prohibit nations from asserting sovereignty in and over space and natural celestial objects.

Another United Nations treaty, the so-called Moon Treaty, came closer to embracing governmental control of private free enterprise in space by assert-

DAVID POVILAITIS

Going where no businessman has gone before ultimately benefits us all, George S. Robinson explains.

ing that outer space and its resources are the "Common Heritage of Mankind." In other words, space is owned by all, to be shared by all. Profits from commercially exploitable space resources would be distributed by an "Enterprise" of governmental officials for the benefit of mankind, with "special consideration" being given to developing countries, as well as those directly contributing to the exploitation—hardly a compelling inducement to the private investor and risk-taking venture capitalist. The principal parties backing the treaty, which was opened for signature in 1979, were the former Soviet Union and its allies, including many lesser-developed countries. The United States and other key spacefaring nations have not signed it.

Of the challenges now being leveled at such concepts—by start-up and mid-level space entrepreneurs in the United States, Western Europe, Australia, and Southeast Asia—one of the more recent and so far successful has come from a U.S. computer/communications entrepreneur, James W. Benson. Benson sold his businesses and retired at a young age, became predictably unchallenged, and was then introduced to the concept of the private development of space resources. His interests led to the establishment of a company called SpaceDev, Inc., which has the ultimate aim of visiting, exploring, assessing, and using asteroid resources.

Although SpaceDev is a young company, it is quite serious about its goals and is moving rapidly to achieve them. It recently accomplished a 100 percent buyout of a young aerospace company, the San Diego-based Integrated Space Systems, acquiring capabilities in mission and spacecraft design, construction, and testing, spacecraft and launch vehicle integration, and ground and mission control and operations.

At a Washington, D.C. news conference in September 1997, Benson announced the formation of SpaceDev's Near Earth Asteroid Prospector mission, a series of deep-space planetary science expeditions. The mission, with its initial launch projected for mid-1999, would involve the first private spacecraft to leave Earth orbit and the first to land on another celestial body. Data derived from NEAP would be sold for profit, and the fruits of robotic resource mining missions—presupposing some form of private ownership of those resources—would also be sold. Indeed, Benson says that pushing this issue is one of the key reasons behind his effort. "I believe that it's very important that a private entity that is privately financed go out and set a precedent for private property rights in space," he said at the conference. "Otherwise, how is industry in the private sector to know that when they go to space to utilize these resources that there will be some validity to their operations?"

Governments can provoke, initiate, and regulate economic development in space but they can't sustain it.

In many respects, grassroots space businesses like Benson's are mimicking the historical undertakings of government-private sector ventures such as the trading companies that were instrumental in the exploration and settlement of the New World: the East India Trading Company, the Virginia Company of London, the Hudson's Bay Company, and so on. Setting aside the negative aspect of economic, military, and cultural imperialism (which we presumably have learned not to repeat), it's easy to see how these undertakings expanded transportation and other communications capabilities necessary for large-scale movements of goods and people into new realms. They allowed and encouraged the construction of railroads, canals, and toll roads; established, encouraged, and protected critical manufacturing capabilities in the New World (such as the creation of limited-liability companies in which the investors were personally protected); and established a privately owned banking system under the control and protection of the federal and state governments.

More recent pioneering efforts should not be disfranchised simply because they do not bear the names of the large, well-heeled aerospace companies. Even those that seem more like stunts, such as a California company's selling of lots on the moon and Mars, are doing a service by raising important legal issues. These companies represent the next generation of private space entrepreneurs and should be encouraged and nurtured—far more than they have been so far by national governments and public international organizations.

We need to remind ourselves of the role they can play amid the realities of the Space Age. With governments continually muscling each other for economic and political advantage and trying to exert various forms of exclusive control and jurisdiction over everything their citizens can and are doing in near and deep space, we risk disfranchising the very people who can ultimately take us there.

Have we learned our lessons on Earth? Is there room on asteroids for the private businessman? There should be.

The author served as an attorney with the Federal Aviation Administration, NASA, and the Smithsonian Institution for over 30 years. He retired in 1995 and opened a law firm in Virginia specializing in aerospace law.

by Dan Kovalchik

Launching a payload into orbit has become nearly a surefire thing. But once in a great while, in a millisecond, both launcher and payload go . . .

Up in Smoke

U.S. AIR FORCE (2)

People who survive an encounter with fate often keep a little souvenir of the event. A common practice is to rescue a bit of the wreckage and immortalize it in Plexiglas.

Because I work as a computer systems administrator for the Boeing Company, builder of the Delta launch vehicles, it's fitting that my souvenir is a "virtual" one, not the type that can be turned into a paperweight. My memento is an e-mail that I can't bring myself to delete from my home computer's inbox. It reads, simply, "Everybody in the blockhouse is alive and well."

I had transmitted this message following the explosion of the Delta II rocket I had just helped launch. The rocket's spectacular failure at an altitude of 1,428 feet was certain to be a hit with the local news, and I wanted to make sure (without tying up the phone lines) that my wife would not be frightened by any sensationalistic coverage.

The blockhouse in question was at Space Launch Complex 17 at the Cape Canaveral Air Station in Florida. I had first visited SLC (or "Slick") 17 in April of 1995 and was astonished to find that both the blockhouse and a number of office buildings sat almost in the shadow of the 125-foot rocket.

SLC-17 obviously owed its design to the early days of the Delta program, back when the rocket was hardly bigger than a telephone pole. By 1995, facility managers realized the rocket's evolution had outpaced the complex's ability to provide a safe haven for its launch crew. Ground was broken for a new launch operations building, a comfortable three miles from the pad.

Meanwhile, there were still payloads to deliver. Thus it came to pass that on January 17, 1997, my crewmates and I once again took our positions inside the blockhouse and heard the loud clang of the giant steel door slamming behind us, sealing us inside.

As usual, the countdown was punctuated by bright red and yellow alarms

DARRELL FISHER

Twelve seconds after a Delta II lifted off launch complex 17 at Cape Canaveral Air Station in January 1997, the rocket and its payload, a Global Positioning System satellite, exploded spectacularly at 1,428 feet.

Some 250 tons of rocket debris rained down on the launch complex, leaving craters and smoldering rubble.

on our computer screens. Engineers quickly addressed the problem areas and gradually extinguished each of the vexing lights. By the final minute, all measurements were within tolerance; the first of a new breed of global positioning satellites (this one named GPS2R-1) was go for launch.

The final minute of a countdown, however, is notorious for its ability to disappoint a launch crew. Any unexpected condition is sure to trigger the dreaded "Hold!" announcement. That unexpected condition can be major, like a computer crash, or minor, like a one-millisecond burst of noise in the telemetry. On a very bad day, the unexpected condition is self-inflicted, like the time we activated the water deluge system on the wrong pad.

But there was no holding GPS2R-1. The first-stage engine roared to life, followed immediately by the ring of strap-on solid rocket motors. The thunder of 710,000 pounds of thrust penetrated the blockhouse, and for a few seconds I felt the familiar vibration of the ground, the console, and the pit of my stomach. Then it faded. The rocket had cleared the pad.

At this point the vehicle was self-sufficient, so most of the crew turned from their consoles to watch the fiery ascent on the TV monitors. Traditionally, this was the time for everyone to resume normal breathing and take pride in a job well done.

My pride lasted all of 12 seconds. As I watched the screen, a brilliant yellow-orange starburst shot up from the bottom of the rocket. In a heartbeat, the thousands of hours invested in building, testing, and launching GPS2R-1 were lost.

The blockhouse crew's collective gasp drowned out the vehicle status reports that had been coming through my headset. I tore my eyes from the TV fireworks and focused on the accusing red lights that filled my computer screen; perhaps one of these alarms held a clue to the catastrophe. Already dreading the post-launch debriefing, I began flicking through the displays, gathering the information I knew our managers would demand.

Suddenly a tremendous explosion shook the blockhouse. I turned back to the monitors only to find them blank. Then came lesser explosions. For the first time it dawned on me that giant chunks of debris were falling on us. I smelled smoke, and I amended my perception to giant chunks of *flaming* debris. This was a surprise; the force of the rocket's destruction had led me to believe that nothing was left but ash and shards of metal.

"LCDR, we're smelling some smoke back here."

Before the LCDR (launch conductor) could answer, another voice came over my headset, this one from our remote telemetry site a few miles away.

"LCDR, better close the vents and be prepared to sit tight. Things are looking pretty intense outside."

These words did little to ease my concern, but at least the explosions had ceased. And since I'd already identified my whiff of smoke as coming from a grass fire, I couldn't imagine the close-cropped grass around the complex as being much of a threat.

"Hey, pictures!" someone called.

I looked up and saw that one TV screen had returned to life. With some relief I saw that the pad and service tower had survived, though it was difficult to assess the damage; the remnants of the dry January grass were still smoldering and a thick gray cloud obscured much of our view.

Still, I was satisfied that our remote observer had exaggerated the situation. I sent the brief e-mail to my wife and returned to the job of information gathering. Gradually, though, the smoke we had smelled inside the blockhouse became clearly visible and at the same

U.S. AIR FORCE (3)

time, much more pungent. The order came to break out the air packs. I unwrapped my pack, slipped it on, and found myself actually amused to be using the lifesaving equipment after 15 years of somewhat dull safety classes.

Just when the blockhouse smoke was approaching a truly alarming level (about an hour after the explosion), I heard the familiar clang of our tomb being opened. Outside, a team of firefighters led us to buses that would take us to the dispensary for observation.

I finally got a first-hand look at the damage. As I expected, smoke still arose from the blackened grass and scrub that surrounded SLC-17. What I had not been able to see on the TV were the gouges and scorch marks left by white-hot chunks of solid rocket propellant. Even the road to the buses was filled with platter-size craters, each rimmed with the white ash of spent propellant.

Behind the blockhouse, I saw why our remote advisor had used the word "intense": A windswept fire still raged, consuming several of our office buildings. Because the vehicle had exploded almost directly overhead, the bulk of the rocket debris had been blown outward, sparing the pad but creating a drop zone of fire that had enveloped practically every structure within the complex—and many of our cars.

I glanced back toward the blockhouse and solved the mystery behind all the smoke we'd been breathing. The cable tray, a concrete trough that ran from the blockhouse wall to the launch pad, had taken a direct hit. A chunk of solid propellant had smashed through the trough's heavy steel cover and started

The Delta II's main engine was one of the larger of the bits and pieces that littered the complex, a bird's-eye view of which is at right.

Risky Business

Back when I was in elementary school, the term "rocket scientist" was not yet a synonym for "genius," and Cape Canaveral was notable only for its spectacular failures. In *The Right Stuff*, Tom Wolfe summarized the American public's perception of the era: *Our rockets always blow up.*

Following one such disaster, my second grade teacher, Mrs. Davenport, found a silver lining in the clouds hanging over the Cape. She used a newspaper story of the rocket's failure as a prelude to a math lesson. With obvious delight, Mrs. Davenport read the accident investigation conclusion: The rocket had self-destructed because of a missing minus sign.

I was far too young to understand the connection between a minus sign and a rocket exploding, but I did learn two very important lessons that day: (1) a rocket is very picky about what you feed it, and (2) scientists should remember their second grade arithmetic.

Nowadays, the art of rocketry is much more reliable. But there's a catch. Launch vehicles are like personal computers: Just when you have your system all figured out, it's obsolete. Someone always wants to put up a bigger satellite. Bigger satellites require bigger rockets. But bigger rockets have more powerful engines, which place more stress on critical parts. Bigger rockets also have bigger fuel tanks and often carry several high-energy solid rocket motors. So, while today's rockets are more likely than ever to ride their column of fire unerringly to the heavens, the occasional failure is more apt to be the Eyewitness News team's dream come true—and the rescue team's nightmare.

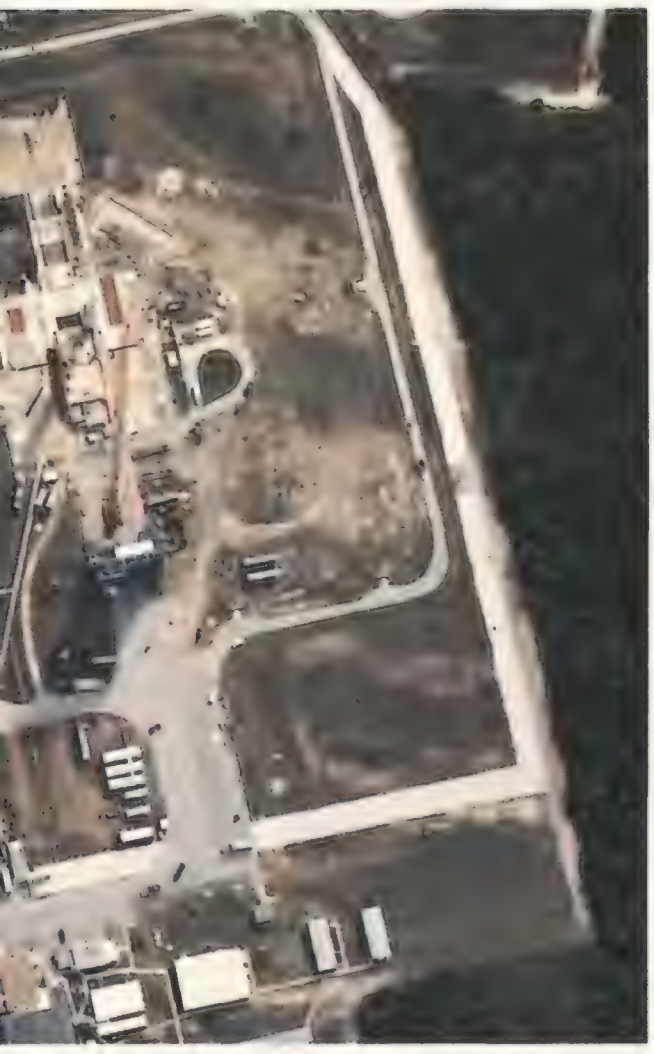
Officials at the Cape Canaveral Air Station long ago decided to accept the risk and invented the range safety organization to deal with it.

Range safety's first order of business is to keep people out of harm's way. To help accomplish this goal, the organization has defined "impact limit lines" around each launch pad. As their name implies, impact limit lines are the magic boundaries beyond which no rocket debris will fall. At their closest point the lines are roughly two miles from the launch pad, which proved to be a sufficient safety margin for the low-altitude, high-intensity Delta II explosion in January 1997. During launch operations, special shelters provide protection for the mission-essential personnel—the only people permitted inside this hazard zone.

Keeping people out of harm's way also pertains to those individuals who might stray into the air-sea corridor. Defining the air corridor is relatively easy: It's the rocket's intended path. The sea corridor is more complicated. Intricate calculations must be performed to map the debris field that would be produced by an explosion.

Further calculations subdivide the debris field into risk zones, based in part upon the likelihood of debris impacts per square foot of ocean. In a departure from the more exotic variables normally associated with rocket science, mathematicians have based this risk assessment upon the dimensions of a shrimp boat.

a roaring fire among the cables. The resulting noxious gases were flowing freely through a bulkhead and into the blockhouse.



Uphill from the fire, a gaping hole marred the slope of the sand used to fortify the blockhouse. A ton or so of solid rocket booster had hit there, cratering the sand and peeling concrete from the blockhouse wall. Had the booster landed just a few feet to the south, the blockhouse roof would have had to absorb the full impact.

Impressed though I was by the damage wrought by 254 tons of falling rocket, these observations of the aftermath were trivial compared to the videotapes of the event itself. At the dispensary, we watched in awe as the TV stations replayed the footage. Each angle showed thousands of streams of fire tumbling from the sky and exploding on impact, toppling trees and sending comet-like fireballs whizzing across the complex. I understood later why my wife was very glad to see me and didn't care that we'd lost our car in the inferno.

The bill to repair SLC-17 was a tough pill to swallow. Nevertheless, having learned that a split in the graphite epoxy casing of one of the solid rocket motors caused the explosion, we've put the accident behind us, as evidenced by the mission patch design for the lost satellite's replacement. In reference to

The SLC-17 parking lot took a hit and a number of cars were consumed by fire, but no one was injured.

GPS2R-1's resting place a mere 51 feet downrange, the GPS2R-2 patch logo reads, "Where no IIR has gone before: To the beach...and beyond!"

And since we're now launching rockets from the safety of the new operations building, I'm guessing (and hoping) that all my future mission souvenirs will be patches, not e-mails. ✈

Shrimp boats have indeed wandered into danger zones and caused launch delays. We consider ourselves lucky. Japan's fishing fleet off the coast of their Tanegashima complex is so large that during fishing season, the Japanese space agency doesn't even try to launch. Japanese rockets lie dormant for nine months out of the year.

Take a clear corridor, a favorable weather report, a few thousand nominal measurements, and the assurances that a dozen rooms full of command and telemetry equipment are functioning and you have the makings of the Miracle of Liftoff.

At this point one of the great ironies of the space business comes into play: While one team is working to put a rocket in the sky, another is poised to bring it down—with extreme prejudice.

This is range safety's second major responsibility: to send a destruct signal to a rocket that has strayed from its flight path. All U.S. orbital rockets are draped with ordnance that can trigger itself or respond via special antennas and receivers to a coded command from range safety. Every rocket team painstakingly installs this suicide kit, thoroughly tests it, and fervently hopes it will drop, unused, into the ocean.

Safeguards like these—and there are many—have been instituted to protect the populace from the effects of failed rockets. And fail they will. It's the nature of the business. When we do suffer a loss, we hope that aside from a costly investigation, all we have to do is sweep rocket parts off the pad and prepare for the next payload. Even sweeping up parts of the launch pad itself is an acceptable consequence as long as we know the failure was limited to a rocket and did not reveal a deficiency in range safety procedures.

In 1987, for example, a lightning strike destroyed an Atlas rocket here at the Cape. The launch crew was safe inside their super-reinforced blockhouse. In 1996 a guidance software bug caused European Space Agency controllers to destroy the first Ariane 5 rocket. Its debris dropped into the secure, uninhabited jungle north of ESA's complex in Kourou, French Guiana.

The team at China's Xichang launch site, however, has lived the ultimate nightmare—twice. In 1995, wind shear brought a Long March rocket down four miles from the pad, killing six and injuring 23. The next year brought an even greater catastrophe. A guidance failure sent another Long March careening into occupied buildings a little over a mile from the launch site. The death toll was 23, with as many as 100 injured.

So although we grouse whenever range safety scrubs a launch, we understand it's for the best. We're committed to safety. We're so committed, for example, that here at Delta launch operations we monitor the health indicators of the rocket's redundant command destruct sytems via two independent telemetry databases. Furthermore, I actually compare these two databases by hand. It's a tedious job, but one that's worth about a hundred million dollars in hardware alone every launch. Mrs. Davenport would be pleased to know that I'm paying particular attention to the minus signs.

Targeted by a B-17, a Japanese carrier dodged the bombs but didn't survive the battle. Today the survival of the island itself is in question. With the Navy gone and tourists now arriving, what does Midway's future hold?

The Battle of Midway, Round Two

Entrepreneurs and naturalists square off on this once-strategic island.

by Bill Marsano

Photographs by Caroline Sheen

NASM

Top: Welcome to former *Naval Air Facility Midway Island. Phoenix Air's Gulfstream brings visitors to the main hangar. One of the first stops on a tour conducted by Fish and Wildlife's James Aliberti is a pair of stone markers commemorating the 1942 battle.*

In June 1942 three Japanese naval forces converged on Midway; 56 years later three forces converge again. This time no carriers lie in ambush. There will be no combat. But there will be a struggle; today's forces mix no better than foreign armadas and the U.S. Pacific Fleet.

Here's the situation: Last June the U.S. Navy closed Naval Air Facility Midway Island, handing the keys (and its $5.5 million annual operating costs) to the Fish and Wildlife Service. The transfer had been set in motion in 1993; soon after, the service began scouting for help in funding a wildlife refuge.

Fish and Wildlife is the first of today's forces. After rejecting developers' proposals to build vacation villas for the super-rich, the Service, also known as Fin & Fur, found Phoenix Air, a military contractor based in Cartersville, Georgia. Phoenix Air's corporate relative, Midway Phoenix Corporation, is offering gas-and-go service for the substantial number of U.S. military and corporate flights that, like so many before them, find Midway a convenient rest stop between the United States and the Far East. Midway Phoenix—Force Two—is also trying to develop limited tourism.

Force Three is History, whose future on Midway is unclear. The Battle of Midway was the critical engagement in the Pacific: On June 4, 1942, Japan began losing the war. But the ships lie full fathom five, and though the victory is immortal, its survivors are not. A single airplane remains (see "Undaunted," p. 67). The few reminders on Midway itself easily go unnoticed.

And so for many, Midway's change of ownership is good news. It makes public a base that since 1941 had been closed to all but the Navy, government leaders, and the cripples of air and sea. In short, the unwelcome mat was out. Ned Titlow, founder of a Midway veterans association, says: "Even the group that put up the plaques had to be in and out the same day."

Now, with the gates flung wide at

Midway Phoenix president Mark Thompson stands at a favorite spot on Sand Island's north beach, perhaps conjuring what he calls "a patriotic titan of industry" who could help him foot the bill for renovating Midway.

last, I went for a week.

It is 1,250 miles north-northwest of Honolulu, a long haul, especially from New York. I boarded a 7 a.m. westbound flight (whose bleary-eyed purser surreally announced that "the captain has fascinated the no-seatbelt sign"), changed planes in Chicago, changed again in Honolulu, and overnighted in Kauai, the northernmost island in the Hawaiian chain. The next day I boarded Phoenix Air's Gulfstream I for the last leg. The Gulfstream—Grumman's first business turboprop, introduced in 1964—had been so thoroughly reconditioned it almost had "new plane" smell. And it was quiet. I dozed fitfully until jolted out of my jet lag by a conversation two rows forward.

"This is a great time to be there," one guy said. "The chicks are gonna be pumped! They'll be strutting around in their semi-adult stage now. With their parents gone, they're getting ready to make their move."

"Great," said his seat mate. "Sounds like we'll see plenty of action."

Midway began to sound far out in more ways than one, but my regrets at having left my disco outfit home faded on landing. The two passengers turned out to be a Fish and Wildlife official and a fervent bird-watcher.

The atoll is about five miles across and covered with birds—in fact, cheek-by-jowl with them, because most of the area is serenely beautiful lagoon. Its principal islands, Sand (about 1,200 acres) and Eastern (335), accommodate more than a million Laysan and black-footed albatrosses alone. These are the infamous "gooney birds," and they plus a dozen other bird species as well as monk seals, green turtles, and other wildlife are the center of the struggle to make of Midway something more than a guano-spattered ex-Navy base.

Although Midway is an island paradise, its atmosphere is resolutely Navy: lots of anchors, framed photographs (signalmen at work, carrier ops, the lighter side of fleet-oiler life), and disarmed ordnance. Navy is also the local dialect. At "billeting," a civilian reception clerk told me: "You're in BOQ Charlie. Have a seat on the torpedo while I get your key." Then he told me how to find the mess hall.

NAVAL HISTORICAL CENTER

Built in 1940 to accommodate the Catalinas that would soon be patrolling the Pacific, Midway's huge seaplane hangar was an easy target for Japanese bombers. The hangar is still little more than a ruin (inset) but has served as a staging area for environmental cleanup crews and is a roomy workshop for Midway Phoenix projects.

Veterans will recognize the place, or not, depending on their dates of service. Hot War Midway was essentially sand, scrub, and runways punctuated by dugouts, pop-gun artillery, and buildings of drably functional design, except for Pan Am's 45-room pre-fab hotel and the telegraph-cable compound, which had lawns, gardens, and even tennis courts.

Midway was a stopover during the brief, brilliant reign of Pan American flying boats. In 1935 a modified Sikorsky S-42, the *Pan American Clipper*, surveyed routes to the Far East through Midway, Wake, and Guam. Other Clippers followed—the magnificent Martin M-130 and Boeing 314. When war came, Midway traded the Clippers for a hastily assembled aviation zoo of Grumman F4F Wildcats and TBF Avengers, Brewster F2A-3 Buffalos, Douglas SBD Dauntlesses, Vought SB2U Vindicators, Martin B-26 Marauders, Boeing B-17 Flying Fortresses, a Curtiss Jenny biplane, and a fleet of Consolidated PBY Catalina flying boats.

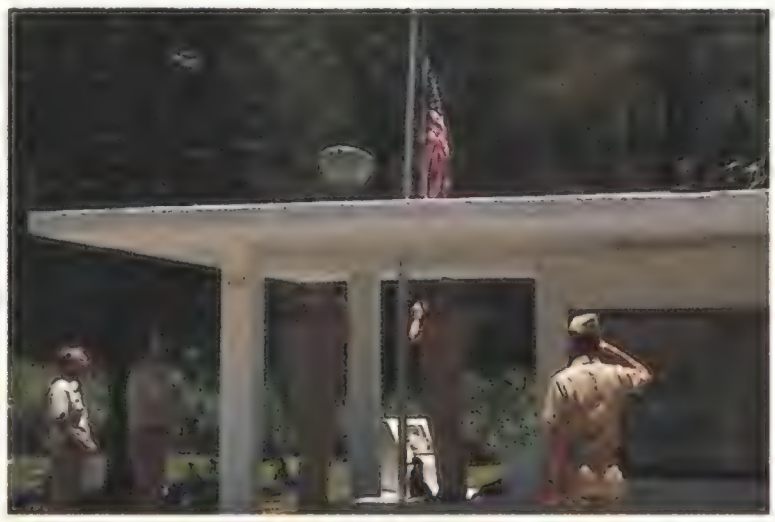
The Catalinas' job was to find the Japanese task forces the Navy's code-breakers at Pearl Harbor had revealed. Flying exhausting 12-hour patrols, they succeeded. Early on June 3 they found the invasion force—and later they attacked it. Four Catalinas never meant for combat, manned by crews untrained in launching torpedos, came in by moonlight and even scored a single modest hit on a tanker.

On June 4, one Catalina spotted a greater threat—the Japanese mobile strike force, with its four aircraft carriers—and another reported: "Many planes heading Midway...." Midway's 26 serviceable fighters rose against more than a hundred attackers; its 55 available bombers attacked the carriers. The fighters suffered a nearly 85 percent loss but blunted the air raid. The bombers (with a loss of about 60 percent) scored no hits—zero—but dangerously disrupted the Japanese plan.

After the hellish half-hour air raid, Midway's combat tour was over, and the Battle of Midway ended later that day at sea. The battlefront moved west, and Midway became a backwater fuel stop for airplanes and submarines.

Cold War Midway, which survives today, is closer to the paradisal model. Ironwood trees imported from Hawaii around the turn of the century proliferated along with pines, palms, and other aliens, giving the atoll a green, park-like look in spots. Traffic was

Last June the Navy handed the island over to the Fish and Wildlife Service during a modest ceremony, with gooneys in attendance. Bottom: A garbage scow abandoned in the 1960s rusts off Sand Island's southern shore.



NASM

This Grumman F4F-3 Wildcat shows battle scars from its tangle with Zeros during the Japanese attack. Of the 26 fighters in the Marine squadron defending the island, only two survived in flying condition.

heavy during the Korean and Vietnam wars, and in between there was the endless drudgery of radar-picket duty against Soviet bombers. Navy WV-2 and -3 Warning Stars (instrument-packed Lockheed Super Constellations) departed Midway at 90-minute intervals. Hurricane-hunting Constellations made fuel stops, as did, later, commercial 707s and U-2 and SR-71 Blackbird spyplanes.

Handling such traffic required a $37 million building program, which was, in 1957, real money. The main runway grew to its current 7,990 feet and the harbor was dredged. A suburban tone set in on Sand Island as quarters for enlisted singles and families were quickly built, two-story houses rose on Commanders' Row, and lawns were laid soon after. The mall sprouted, with its theater, base exchange, officers' clubs, and bowling alley. The hospital logged births; the high school, graduations. Base population peaked at 2,657. Midway was part paradise yet all military, its ethos written on the chapel doormat: "Enter and Pray" going in; "Leave and Serve" coming out.

The chapel fell to termites some years back, and all the rest would be razed to the ground if Fin & Fur had its druthers. Wildlife refuges are sanctuaries with little place for man and none at all for anything known, in eco-speak, as "non-indigenous." Alien vegetation is truly bird-hostile.

On Eastern Island, which the Navy abandoned in 1970, the threat is clear.

NATIONAL MUSEUM OF NAVAL AVIATION

Undaunted

In October 1993, salvors working for the National Museum of Naval Aviation in Pensacola, Florida, found in Lake Michigan a rarity: a Douglas SBD-2 Dauntless dive bomber. Like 29 other aircraft that have been pulled from the lake, the Dauntless had been assigned to Naval Air Station Glenview, just north of Chicago, and was lost in a training accident. Once museum curators got a look at the Dauntless, however, they realized they had found something unique. On its cowling was the stenciled name *Midway Madness.*

Carrier-borne Dauntlesses were the heroes at Midway, turning the Japanese carriers *Akagi*, *Kaga*, and *Soryu* into flaming wreckage within four minutes on the morning of June 4 and nailing *Hiryu* some hours later. Museum staff checking out bureau numbers and unit histories learned their Dauntless had not been one of them. Instead, *Midway Madness* flew in the battle from the island itself, part of VMSB-241, a mixed squadron that included Vought SB2U-3 Vindicators (known to their unhappy crews as "Wind Indicators").

VMSB-241 took off at 6:10 a.m. June 4 and was over the enemy carriers in less than two hours. Because his pilots were inexperienced in dive-bombing and only three had time in a Dauntless, the squadron leader, Marine Major Lofton R. Henderson, chose a glide-bombing attack because it was easier to execute. It was also riskier. In the shallow glide, the aircraft were more vulnerable to Zeros and anti-aircraft fire for a longer period than the preferred 70-degree "hell dive." VMSB-241 scored no hits and the squadron was shredded. Henderson was among the many lost.

That *Midway Madness* brought her crew home is almost a miracle. Two Zeros occupied her gunner, Private First Class Wallace Reid, as First Lieutenant Dan Iverson dove to 300 feet before dropping his bomb (a near-miss astern of a carrier); then two more Zeros joined them. Bullets smashed the instrument panel and severed Iverson's throat mike. Sometime after he managed to land, the bullet holes were counted. There were more than 200.

Midway Madness' post-battle survival also seems miraculous. Most badly shot-up airplanes were junked on site or, if carrier-borne, pushed over the side, but *Midway Madness* was sent by ship to San Diego instead; from there it went to Glenview and then Lake Michigan.

The aircraft is now undergoing restoration and may remind the visitors to Pensacola's museum that although tactics and weaponry are important to survival, luck doesn't hurt either.

Phoenix has cleared 4,000 feet of its wartime runway for emergency use, but otherwise Eastern has gone to seed, with exotic plant life spreading like something out of *Day of the Triffids.*

Fish and Wildlife's James Aliberti says verbesina overwhelms naupaka, the native habitat of foliage-nesters like the black noddys, great frigates, and red-footed boobies. It threatens ground nesters too. Naupaka-deprived shearwaters, red-tailed tropicbirds, and even some gooney birds must instead shelter under verbesina, which in summer quickly shrivels and dies, leaving eggs and chicks to cook in the hammering sunlight.

As for the ironwoods, known elsewhere as Australian pines and casuarinas, they shape and relieve a landscape that is flat where it isn't flatter. Fin & Fur isn't fooled. Ironwoods kill albatrosses, whose six-foot wingspread makes them poetry in flight but rank doggerel on landing. Their best touchdowns are likely to be protracted crash-and-roll affairs, if they haven't barreled into the ironwoods first. (Or a hapless visitor. Only on Midway have I had to sign a liability waiver that says "large flying birds may collide with guests.")

NAVAL HISTORICAL CENTER

In the 1940s, Eastern Island (inset, foreground) was all runways. A recent aerial photo shows that today, it's almost all vegetation. But people who have returned to Midway say the changes in the islands over the years are less noticeable than the constants: the small-town atmosphere and the feeling one gets of a safe haven.

Refuge manager Rob Shallenberger makes F&F's case: "Our job is habitat restoration. To simply maintain status quo is to be custodians of damaged property. And status quo doesn't exist. The ironwoods keep spreading. Aerial photos from 1981 show very few on Eastern, while the number we have now is amazing."

"We aren't going to lose any ironwoods on Sand if I can help it," says Phoenix Air's president, Mark Thompson, a former U.S. Army helicopter pilot, entrepreneur, sportsman, and (probable) millionaire. A terse and soft-spoken Georgian, Thompson makes noise only when racing stock cars. His only brush with publicity was a brief appearance in 1994 on the national evening news when he crashed a race car in Daytona at 190 mph.

In 1974 he founded Georgia Air, which evolved into Phoenix Air and serviced oil drillers from Cartersville ("the only town that would let me store explosives at the airport"). In time Phoenix branched into military work—live-fire target towing and electronic-warfare training—for the Navy, NATO, and, ironically, the Japanese navy. That is about all Thompson volunteers about the "worldwide aircraft services" noted on his business card.

It is enough to explain interest in a mid-ocean air base with a name (Henderson Field-Sand Island Airport, Midway Atoll National Wildlife Refuge) even longer than its runways, which are 7,900, 5,777, and 4,500 feet, plus overruns. The airport has GPS approaches plus a TACAN—tactical air navigation—radio-approach system as a navaid for military airplanes, like the C-5A that ferried the Navy out last summer. What with Phoenix's tourist flights, occasional emergencies, pit stops by Lockheed P-3 Orion patrol craft from the U.S. and Canada, and corporate jets from everywhere ("We turn Gulfstream IVs in 35 minutes," Thompson says), there's enough traffic to stave off boredom, though it's hardly what it was during Vietnam, when the Navy annually logged thousands of flights.

There's also the possibility that Midway could become important again some day. Asian crises natural or man-made could again require the shipping of large amounts of men and materiel, and the atoll is at the corner of a 200-mile zone reserved for U.S. commercial fishing—an exclusion that may one day require

the Service, and it's important that it work." Thompson says: "It's like a marriage. We have to get along."

So far they do. Fin & Fur plans total war against the aliens on Eastern but treads lightly on Sand Island, where it has eradicated the egg-eating rats and will rip out alien shrubs but leave the ironwoods and other trees alone. (Indeed, it has laid walking trails among them.) The small flocks of mynah birds and canaries, descendants of escaped pets, are probably safe too, even though Shallenberger, keeping his indictment warm, says, "They do spread alien seeds." Visitors will be limited to 100 at any given time, and to serve them Thompson has been allowed to renovate bachelor officers' quarters Baker and Charlie and to build a few small, neat structures.

Two are on the Navy-built inner harbor: a dive shop and a game-fishing operation with powerful boats plying waters full of blue marlin, swordfish, tuna, ulua, amberjack, and other fish. The north shore's magnificent powder beach has a pavilion and, as a supplement to the mess hall, the Clipper House restaurant, whose name and decor recall Pan Am's great days. During my visit, its food was superb, fresh, and imaginative. Thompson, who has a hypnotic way with the words "remote Pacific island," apparently uttered them within earshot of a young chef from southwestern France.

So is anybody coming?

Yes. Early arrivals included travel writers of the sort who write newspaper stories headed "Surprising Tucson" and "Sacramento's Bold New Look." They spread the word and some hilarious errors. (For the record, Midway is not northeast of Honolulu, and the "downed freighter" offshore is an abandoned scow.) Still, they've attracted even more enforcement by the Coast Guard aircraft now fueling at Midway. Finally, the international aviation code requires twin-engine trans-Pacific jets to fly within at least three hours, at single-engine speed, of an emergency strip. Midway is well placed for such dramas. A memorable one occurred in 1991, when a Philippine volcano erupted and a Pan Am 747 inhaled its ash plume. Some 300 passengers and crew were profoundly grateful for Midway.

Under such circumstances, the island could generate income, but for now it produces only outgo. Thompson says his venture is "altruistic, even if it is the only altruistic thing I've ever done. Maybe it's atonement for past sins. The idea that nobody could go out there anymore just seemed wrong.

"I need to break even here, but I'm not trying to make money on Midway. This place casts a spell, and I sort of fell in love with it." His board of directors didn't, but "hell, *I'm* the president," he says.

The sticky part is that commerce and wildlife are in 180-degree opposition but partnered 50-50. "We didn't sign a contract," says Rob Shallenberger. "It's a cooperative agreement. It's a first for

Although gooney birds—albatrosses—impress birdwatching tourists with their personalities (and numbers), Midway is home to 14 other species of birds, including white terns (bottom, left) and red-tailed tropicbirds.

NATIONAL ARCHIVES

Fish and Wildlife's Rob Shallenberger and friend check out the entrance to an underground command post, where Navy and Marine officers sought cover during the Japanese air raid. Admiral Chester Nimitz (right) surveyed the island's defenses a month before the attack, knowing that victory could depend on the stand at Midway.

some trade. Phoenix Air's 19-passenger Gulfstream now makes the trip from Kauai twice a week and, beginning this month, will be joined weekly by an Aloha Airlines 737. They bring scuba divers, a few sport fishermen, and bird watchers who are usually stunned to silence by avian profusion.

Veterans? Not many. Midway is distant for all of them and expensive for most. One veteran who decided against a journey back is representative. Retired Marine Lieutenant William Brooks of Bellevue, Nebraska, is one of the few (very few) entitled to an "I Survived Combat in a Brewster Buffalo" T-shirt. He recalls arriving on Midway "a couple of days before the battle, a brand-new pilot with just a few hours' experience in type." He's "thought about" visiting, but says "I'm getting along in years to the point that traveling wears me out."

There are growing numbers of ecotourists. College groups and adults with Elderhostel and Oceanic Society Expeditions volunteer for research projects. They do scut work—the no-experience-necessary jobs, like "habitat restoration" (that means "replanting native shrubs" but may also require ripping out the #$%&* verbesina first). Every volunteer I met was delighted to pitch in, despite occasional bites from cranky black-footed albatrosses.

I fell under Midway's spell even as I wondered what on earth I would do there. I did nothing and liked it. I spent hours at the beach, watching the horizon widen as if the concept of an expanding universe were being demonstrated for my personal benefit. Beyond that horizon, many miles northeast, is Point Luck, where *Yorktown*, *Enterprise*, and *Hornet*, the three carriers our Navy could muster, lay in ambush; some miles southwest of Point Luck,

The only sea battle around Midway today is between fisherman and fish: Midway Sport Fishing offers catch-and-release charters (left). Spinner dolphins are among the friendlier noncombatants.

their squadrons met the Japanese.

For a long time it was a terrible business. Planes got lost; fighter cover was dispersed; attacks weren't coordinated; bombs simply fell off airplanes when pilots armed their release mechanisms; Zeros seemed to be everywhere. The torpedo bombers got the worst of it; they flew long, slow, straight-line target runs that trapped them between the Zeros and intense shipborne anti-aircraft fire. Our airplanes seemed to fall out of the sky in ones, in twos, in great flaming handfuls.

Again the Americans scored no hits—until a passel of Dauntlesses arrived,

NASM

U.S. Navy P-3 Orions (above) stop over at Midway on long-range missions today, just as Army B-24 bombers (left) did during World War II. Besides running the refueling operation, Midway Phoenix Corporation provides medevac services, bringing in patients from ships and transporting them to Hawaii (below).

undetected by the Zeros, which were still shooting up the torpedo bombers. In four minutes three carriers became furnaces of gasoline-fed flames and exploding ordnance. A fourth escaped detection long enough to launch strikes that doomed the *Yorktown*, but by day's end that ship, too, was finished.

Midway today gives no hint of such events. It's a blend of "Mayberry R.F.D." and "Ozzie and Harriet"—unlocked doors, everyone hand-waving friendly in a low-key, good-neighbor way.

"No sweat" is the house rule. A medevac operation—for an injured seaman from a Japanese fishing boat—went off like sleepwalking. Thompson is proud of such at-sea rescues, which average two a month, but so modest about them that I almost missed this one. They are treated like the other jobs needed to keep a small town functioning: bringing in supplies, maintaining grounds, providing medical services, even, under certain circumstances, interacting with wildlife.

Animals seldom interest me except when they are "plated," as they say in the restaurant trade, but Midway's won me over. By Day Two I had adopted a red-tailed tropicbird and chick I discovered near the mall and was photographing white-tern chicks in their nest. Soon I was clearing gooneys from the runways with Cell-Tel Bill, a Midway Phoenix employee named for his telephonic genius. An Australian Crocodile Dundee type, Cell-Tel has branched into this

NAVAL HISTORICAL CENTER

peculiar job and several others because, he says, "I plan to stay here quite some time."

Gooneys are not "unafraid" of man; they ignore him. During the Japanese raid, most simply hunkered down unless a bomb practically fell on them. Their confidence in having the right of way led to expensive and dangerous "strikes," in which they got sucked into air intakes and wrecked engines. (Only the albatrosses cause such damage. Midway's smaller birds, I was told, are "more digestible.") For years the Navy tried to be neighborly about that—absurdly so on one occasion.

Gooneys don't actually nest but merely squat anywhere and lay eggs. It's not much, but they call it home—insistently. They are in fact driven to find exactly the same site when returning from years on the wing. Even today Phoenix folk find them wandering around in the hangar, looking for home. The Navy, however, thought gooneys were merely runway-addicted, and so once tried luring them to Kure Atoll, 60 miles away, where the Seabees, the Navy's construction battalions, had built new nesting sites. The part that suggests Naval derangement is that the Seabees also built a fake runway, complete with paved approaches. Then everyone sat and waited for the birds to flock to the runway on Kure, leaving Naval Air Facility Midway gooney-free at last.

That was in 1959.

By January 1964 the 2,100 bird strikes

Midway's stalwart inhabitants were impervious to the bombing (above). For a Navy documentary, director John Ford filmed the attack from the power house, which still stands (upper inset). The cable company buildings are also still standing, though overgrown by banyan trees (lower inset). One last gun stands alone on Eastern, except when visited by tourists and, of course...

on the books had the Navy in an ugly mood. Gunfire, explosives, egg-napping, bulldozers and, finally, industrial-scale murder produced varying degrees of success. Today such methods fly in the face of F&F policy: Do not stress the wildlife! Do not impact the wildlife! To avoid stressing pilots and impacting airplanes, albatrosses are still cleared, but with kindness, one at a time. Cell-Tel and I would approach slowly (not from behind—they are skilled projectile defecators) and perform an arm-waving, leg-shuffling dance accompanied by strange cries. Soon the birds would move off, and who could blame them?

All very well; as a place to visit, Midway deserves the hack travel writer's favorite adjective, "unique," and first alternate, "magical." But where is history in all this? What conveys the importance and cost of the greatest victory at sea since Nelson at Trafalgar?

Sand Island has its formal memorials and withering remnants: gun emplacements, ammunition magazines, pillboxes fabricated from tank turrets, bullet holes, splinter scars. On Eastern Island a rusting anti-aircraft gun stands, neither an abandoned leftover nor a ceremonial monument but a soldier's tribute. Someone who knew what he was doing ordered that one last gun to be left behind to recall the 2,227 men who were determined to repel an invasion force of overwhelming strength.

The relics don't amount to much; they can't. The past must be taught if it is to have meaning for the future. To that end, Oceanic Society Expeditions has two historical tours scheduled for next year. The normally cool Mark Thompson warms noticeably when he points out: "The Arizona Memorial at Pearl is fine, but it commemorates defeat. Something's wrong when we have just a few plaques for our greatest victory." In time he hopes to "do something." At this point, though, he's not sure what.

Maybe some day a corporate philanthropist will underwrite a permanent exhibition, detailed and vivid, in the mall's homely shoebox of a theater. The centerpiece would be director John Ford's movie footage of the Japanese attack, part of a 1942 Navy documentary. (It's hair-raising stuff. Ford, in an exposed position in the power house, was wounded, but he kept on filming.) The frame would be the theater's murals, executed by an artist who signed his work V.N. Solander.

The murals seem conventional recruiting-poster stuff at first. They include a carrier with a deckload of airplanes, a PT Boat and a heavy cruiser at flank speed, a sub loading torpedos. But one of them has a poignant honesty. It shows that Solander must have consulted his conscience over glorifying what it was like to fight in the Pacific. It's the third panel on the left, of Marines storming a beach, that makes a statement. You have to look twice to see that one of the Marines is face down in the sand.

Midway casts a spell, its visitors say. As at other battlegrounds, like Gettysburg and Verdun, the beauty of the place is made more captivating by its history.

BRIAN McLEOD

ERIC LONG

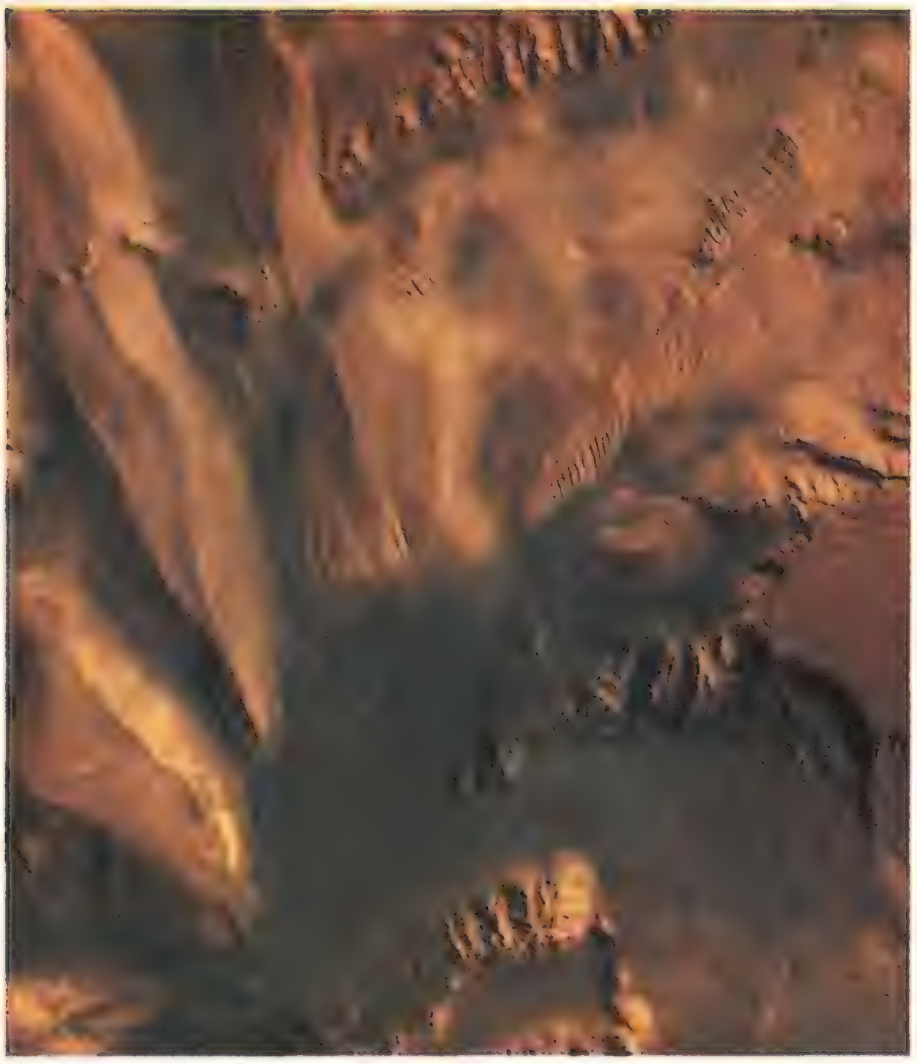
>SIGHTINGS<

In a dramatic demonstration of the "gravitational lens" effect, the Smithsonian Institution's Castle is warped like a fun-house mirror image. Brian McLeod of the Harvard-Smithsonian Center for Astrophysics created this computer-manipulated image for a session on gravitational lenses at an American Astronomical Society meeting in Washington, D.C., last January.

In this phenomenon, predicted by Einstein's Theory of General Relativity, light rays from a distant object, such as a quasar, are bent by the gravitational field of an object in the foreground—say, a galaxy—and ultimately distort the background object.

To demonstrate the effect on an Earthly scale, McLeod used a digitized photo of the Castle and applied software to distort the image as if a black hole the size of Saturn had occupied the National Mall in Washington, D.C. (The accompanying press release notes, "We're ignoring the fact that the gravitational force from such a black hole would do some serious damage to the Castle and its surroundings.") The result is an elongated Castle embracing an upside-down and mirror-reversed one.

Red Planet Reading



CEPS/NASM

The Planet Mars: A History of Observation and Discovery *by William Sheehan. University of Arizona Press, 1996. 270 pp., $45.00 (hardcover) $19.95 (paperback).*

On the night before Halloween 1938, Orson Welles, with the aid of the Mercury Theater company and Welles' flair for the dramatic, scared the wits out of a great many people. When the audience heard a radio broadcast apparently reporting a Martian invasion of Earth, approximately two million of them mistook the broadcast for the real thing.

The response to Welles' broadcast is vivid proof of our deep-seated fascination with the possibilities of life beyond Earth, and life on Mars in particular, a fascination that countless movies, television shows, and science fiction novels show no sign of exhausting. But such fascination has entranced more than writers and movie producers.

Animated debates among scientists in the 19th and early 20th centuries about the possibility that canals criss-cross the planet foreshadowed the enormous interest in the landings of the Viking spacecraft on Mars in 1976, the claims about the detection of evidence of life in meteorites from Mars, and, most recently, the *Pathfinder* mission and the wanderings of its robotic rover over the planet's surface.

Anyone who would like to know more about the remarkable history of attempts to understand the Red Planet would do well to begin with William Sheehan's *The Planet Mars*. Starting from the earliest times, Sheehan carries his story through the Space Age.

As Sheehan recounts, spacecraft sent to the planet by the United States (Soviet and Russian efforts to reach Mars and its moons have been much less successful) have radically transformed our views of the planet. Spacecraft put an end to talk of canals once and for all. But they also revealed a planet covered by craters, huge volcanoes, and an enormous canyon system that dwarfs anything remotely like it on Earth. With a string of other spacecraft following hard on the heels of Pathfinder, the history of our exploration of Mars has only begun.

—Robert W. Smith is the chairman of the space history department at the National Air and Space Museum.

Destination Mars: In Art, Myth, and Science *by Martin Caidin, Jay Barbree, and Susan Wright. Penguin Studio, 1997, 228 pp., $29.95.*

Never has the angry red planet been so lovingly displayed as it is in this visually rich little book. The authors—the late Martin Caidin, well known among readers of aviation and space fact and fiction, Jay Barbree, a familiar NBC television correspondent from the Apollo era, and Susan Wright, *Star Trek* novelist and writer on Georgia O'Keeffe—try to blend fact and fiction as they trace the infatuation various Earthbound cultures have felt throughout history for the planet Mars, and what they have learned about the planet in the process.

Though the book is largely chronological, the authors bound back and forth through time recounting how Mars has come center stage time and again, using Orson Welles' 1938 broadcast of "War of the Worlds" as their framework for exploring deep-rooted fears of invasion by superior forces, the image of Mars as the bringer of war, the Roman cult of Mars, and past and present views of life on other planets, including Mars itself. They weave a fanciful tapestry of the image and role of Mars in Christian thought, astrology, the Renaissance, the Reformation, the industrial age, and the 20th century, while tying in our expanding knowledge of the planet itself. The authors also cover the ancient iconography of Mars as represented in literature, art, and science fiction, both on the printed page and in the cinema.

Sadly, what could have been a terrific book is marred by the authors' confusion of fact with fiction. Errors stem from poor editing, strange inclusions, diversions, premature overstatements, and outright blunders. Blinding their vision is a belief that Mars can be terraformed; many

errors creep in to help them make this leap of faith.

For those annoyed by such silliness, look elsewhere. For those who harbor an unshakable romantic vision of humans someday becoming the first real Martians, this is your book.

—David DeVorkin is a curator in the space history department at the National Air and Space Museum.

Japanese Army Air Force Aces, 1937–45 *by Henry Sakaida. Osprey (distributed in U.S. by Specialty Book Marketing), 1997. 96 pp., b&w and color photos and illustrations, $16.95 (paperback).*

Luftwaffe fighter ace Eric Hartmann has a more devoted following today than he had in the 1940s, *Das Boot* recently enjoyed another run at the art houses, and even a book on German firefighting vehicles of World War II finds a ready market among war buffs.

Imperial Japan has no such following, although it went to war two years before Germany did—and was still fighting when Germany surrendered. How many Americans can name a Japanese ace other than Saburo Sakai? How many know that Japan had two air forces, each with its own aircraft and traditions?

The Japanese Army Air Force (JAAF) fought half a dozen bitter campaigns, including a 1939 border war with Russia and the last, hopeless struggle to protect the homeland from hordes of Boeing B-29s. "Finally, I sighted an enemy four-engined bomber," recalls Captain Isamu Kashiide about the first time the giants appeared over Iwata. "I was scared. It was known that the B-29 was a huge plane, but when I saw my opponent it was much larger than I had ever expected!"

This volume profiles each of the major JAAF aces, including the durable Yohei Hinoki (his name means "tree of the sun," the beautiful ground cypress of Japan). Hinoki fought the Flying Tigers in Burma, lost his right leg in an encounter with a P-51 Mustang, but survived to fly again. His final combat is pictured on the cover: his radial engine Kawasaki Ki-100 winging victorious over a P-51 supposedly flown by Captain John Benbow, who vanished over Nagoya in the war's last month.

There are color illustrations of JAAF fighters, a list of aces beginning with Warrant Officer Hiromichi Shinohara, and a telling example that shows why Japanese victory claims are even more inflated than those of other nations.

Exaggerators or not, these pilots are worth knowing. We owe a debt to Henry Sakaida, an American who learned Japanese so he could research these matters, and to the Osprey publishers for publishing his project in one of its compact, yet handsome volumes subtitled *Aircraft of the Aces*, of which this is number 13.

—Daniel Ford studied JAAF operations as a Verville Fellow at the National Air and Space Museum. He wrote "The Sorry Saga of the Brewster Buffalo" in the June/July 1996 issue.

Warpath: A Story of the 345th Bombardment Group (M) in World War II *by Schiffer Publishing. 1997, 299 pp., b&w photos, $49.95 (hardcover).*

Warpath is a history of an unusual World War II bomb group. These men bombed and strafed Japanese targets at altitudes as low as 20 feet and at speeds as high as 240 mph, employing innovative tactics and weapons. They flew the North American B-25 Mitchell, a medium bomber designed to operate thousands of feet higher. A passage on page 30 sums up the Air Apache mission: "We came upon our enemy with sudden speed and without

SECOND LOOK

MiG: Fifty Years of Secret Aircraft Design *by R.A. Belyakov and J. Marmain. Naval Institute Press, 1994. 479 pp., b&w photos and drawings, $44.95.*

In 1956, MiG's sleek new I-3U supersonic interceptor never even taxied out for takeoff: Its intended engine had failed its tests. And for years, the specially developed high-altitude MiG-19SV could not reach the American U-2, which would finally be shot down by an early Soviet surface-to-air missile.

But along with such frustrations, we read in *MiG: Fifty Years of Secret Aircraft Design* of innovations that led to impressive achievements—from the 47,000-ft. altitude reached by MiG's experimental I-222 interceptor in World War II to the first flight of the Mach 3 MiG-25 prototype over 33 years ago.

An acronym for the names Artem Mikoyan (chief designer) and Mikhail Guryevich (chief constructor), the MiG design bureau spun off from the famed Polikarpov OKB in 1939. Guryevich retired in 1964; Mikoyan, with Rostislav Belyakov rising to first deputy, ran the bureau until his death in 1970, when Belyakov took over.

Supported by numerous one-of-a-kind photographs, excellent three-view line drawings, and helpful tables (engines, radar types, weaponry, etc.), the text offers fascinating case studies in the evolution of MiG aircraft designs. Updated since its original publication in France several years ago, this edition explains how MiG nomenclature provided deliberate misinformation to the West during the cold war, and it reveals previously classified details about the MiG-31M long-range Mach 3 interceptor, which can be used as a mini-AWACS (Airborne Warning And Control System) to control a supersonic four-MiG formation radar sweep along a 560-mile front.

The book's weaknesses lie in its index and in the authors' lack of historical accuracy. They state that in 1967 the MiG-23 became the first airplane with variable-sweep wings and a folding ventral fin, and that in 1951 the MiG-17F had the first afterburner—plus other such examples. Yet the Bell X-5 flew with variable-sweep wings in 1951, Chance Vought's F8U-3 prototype featured a folding ventral fin in 1958, and the first afterburner-equipped Lockheed F-94A flew two years before the MiG-17F.

Nevertheless, we read about scores of innovative concepts, some discarded after testing: potential diesel powerplants for a World War II escort fighter; experimental vertically swiveling cannon installed in the nose and along the forward fuselage of two different prototype jet fighters; even escort fighters to be towed (with engines shut off) by the bombers they were to protect. Not to mention the blended wing-body design of the MiG-29 (40 percent of total lift coming from its fuselage), the helmet-mounted target designator for its pilot (not yet in U.S. production fighters), clever engine intake screens and landing gear mudguards to prevent foreign-object damage during rough-field takeoffs and landings, and the use of difficult-to-machine aluminum-lithium alloy (abandoned by Boeing for its new 777).

That just scratches the surface. For those interested in the history and technology of aircraft design, this is a superb (and readable) book on one of the world's premier aircraft manufacturers.

—Theodore L. Gaillard Jr. is a Philadelphia-based writer on military technology.

warning. Unlike many Air Corps units, we could see our foe as he trained his guns on us or ran for cover. We could see him fall as our strafing swept through his bivouacs. Our brand of warfare was somewhat akin to the infantry and distinctly removed from the remoteness of bombing from 10,000 feet."

At low level, it was hard for either attacker or defender to miss. Even training flights could be lethal. The unit lost 712 men during three years in action, 580 in aerial combat.

At war's end, the Fifth Air Force bestowed a special honor on the 345th: The unit was allowed to choose one B-25 from each of its four squadrons to intercept and escort the first Japanese peace delegation flying to Manila, via the Air Apache base at Ie Shima.

Despite their losses, the Air Apaches posted an extraordinary tally. They concentrated their attacks on airfields and harbors, sinking 190,000 tons of Japanese shipping and damaging 275 other vessels. A total of 260 Japanese aircraft were strafed or bombed to destruction. Another 107 fell in aerial combat, while 177 Mitchells were lost. The unit employed some unique weapons, including a nose modification for eight heavy machine guns, and the aircraft also carried fragmentation bombs equipped with parachutes to delay detonation.

Beneath the tail of each Mitchell, mechanics installed another Air Apache innovation: a K-12 automatic camera shooting a four-by-six-inch frame each second during an attack run. Today these photographs are among the most vivid images of low-level aerial combat ever recorded.

Warpath follows the Schiffer publishing company's recent trend of reprinting unit histories verbatim. Originally published in 1946, only the full-color cover, slick paper, and binding are new in this edition. Missing text on page 12 is a trivial glitch that no doubt plagued the original. Poor-quality photographs are the major failing. To view the K-12 photos in their original, large-format splendor, the aviation enthusiast must look elsewhere. The source is Lawrence J. Hickey's monumental work, *Warpath Across the Pacific: The Illustrated History of the 345th Bombardment Group During World War II*. Schiffer's *Warpath* excels in nostalgia, portraying the men, their living conditions, and their off-duty antics.

The book is divided into two sections. The first is an operational history of the 345th followed by accounts about each squadron. The human side isn't forgotten, as shown in a passage summing up the squadron's departure from California to join the war: "A last glance at the receding 'Frisco skyline, a wistful look at the majestic Golden Gate bridge, and we turned our thoughts to the months that lay ahead and the adventures they were to bring. Was this to be our last glimpse of America? Would it fall to us to be one of those who were to make the total sacrifice?"

This book is recommended not for its nuts-and-bolts analysis of aircraft and air combat, although it does touch on these points. *Warpath: A Story of the 345th Bombardment Group (M) in World War II* is a unit history worth reading mainly for its vivid portrayal of the thoughts and feelings of people caught up in the Pacific air war.

—Russell Lee is a curator in the aeronautics department at the National Air and Space Museum.

PREVIEW

MYLES ARONOWITZ/PARAMOUNT

Deep Impact *Dreamworks/ Paramount, opening May 1998. Starring Morgan Freeman, Robert Duvall, Tea Leoni, Elijah Wood, Vanessa Redgrave, and Leelee Sobieski.*

"How would you live today, tomorrow, next week, if you knew the world might end in a year?" That's the question this film poses, in the form of a comet that will collide with Earth—unless a team of astronauts led by Robert Duvall's character deflect it. Drawing on the expanding body of knowledge about historic asteroid and comet impacts on Earth and other planets, the film also taps some top technical advice from Gerald Griffin, former director of NASA's Johnson Space Center in Houston. Griffin was previously involved in the film *Apollo 13* and the science fiction feature *Contact*. Recently retired astronaut David Walker also consulted on the film.

—George C. Larson is the editor of Air & Space/Smithsonian.

ON VIDEO

Discover Soaring! A Transition to Gliders. *Produced and written by David Treinis, directed by Kevin May. Niche A/V Inc., 1997. 39 min., $24.95 (VHS).*

Discover Soaring! provides a look into the spectacular adventure of taking to the air without the aid of an engine. Complete with a brief historical

sequence featuring footage that highlights non-powered aerial records and achievements, *Discover Soaring!* covers flying a glider in both typical and emergency situations, and also breaks down the physics of flight through several hands-on demonstrations in the glider. Included is an overview of the variety of clubs and competitions open to novice and experienced glider pilots worldwide.

The Thunderbirds: Thunder Over the Pacific. *Produced by Vienna Productions, Inc., for the History Channel. Produced and written by Rob Stone and Kris "Hoot" Bergens, hosted by Candice Bergen. A&E Home Video and the History Channel, 1997. 100 min. (VHS).*

Flying less than 18 inches from each other, the U.S. Air Force Thunderbirds zip through the sky in unbelievable splendor. This

marvelous film is fast, fun, exciting, and awe-inspiring as six elite fighter pilots reveal what it takes to drill holes in the sky in their F-16 Fighting Falcons. Crew members and pilots give a behind-the-scenes look at Thunderbird maneuvers, the pilots' thoughts while airborne, and all the preparation that goes into each performance. The video highlights the team's recent trans-Pacific tour of Alaska, Japan, Korea, Thailand, Malaysia, and Guam. *Thunder Over the Pacific* puts the viewer in the backseat for an exciting ride.

—Dave Schall is an intern at Air & Space/Smithsonian. *He is studying journalism at Loyola College in Baltimore.*

AIR&SPACE

CLASSIFIED

CLASSIFIED RATES: $11.00 per word-15 words or $165. minimum (net.) Ads over 30 words will be billed at the agate rate. Phone numbers are two words, as are box numbers. Zip codes count as one word. Adjustments will be made on word-counts if necessary.

Frequency rates per word:
3x—$10.50 6x—$10.00
Payment required with order (DISCOVER/ VISA/ MC/ AMERICAN EXPRESS check or money order.)

Deadlines seventh of each month, two months prior to issue date. All advertisements must be accompanied by name, address, and telephone number.

BOLD PRINT is limited to first 3 words of ad–ONLY.

AIR&SPACE/Smithsonian reserves the right to refuse any advertisement considered inappropriate.

Please send materials and payment to:

AIR&SPACE/Smithsonian
697 Fawn Drive
San Anselmo, CA 94960
(415) 454-9782
Fax (415) 454-9785
airspacemag@marinternet.com

CLASSIFIED

NEARLY ONE MILLION readers and potential customers will see your products by advertising in the new AIR&SPACE/Smithsonian Magazine classified section. (A few sample headings are listed below.) Fill out the form to the right or call (415) 454-9782 for further details about this special opportunity.

AVIATION ART

AIRCRAFT BOOKS

AIRCRAFT SALES/TRADES

FLIGHT SCHOOLS

A new advertising opportunity from AIR&SPACE Magazine.

Introducing the new classified section in AIR&SPACE Magazine. For as little as $165 (per insertion) you'll reach nearly one million prospective new customers, who are eager to try your product. Just fill out this form, indicate method of payment and mail to:

AIR&SPACE

AIR&SPACE/Smithsonian • 697 Fawn Drive • San Anselmo, CA 94960
(415) 454-9782 • Fax (415) 454-9785 • airspacemag@marinternet.com

AD CLASSIFICATION: *(Check one)*

❑*Aviation Art* ❑*Aviation Books/Tapes/Videos* ❑*Aviation Models*
❑*Aircraft Sales/Trades* ❑*Business Opportunities* ❑*Flight Schools* ❑*Miscellaneous*
❑*Vacation/Travel* ❑*Events/Conferences*

IN THE_____ISSUE(S).

CLOSING DATES:
June/July—April 14 Aug/Sept—June 7 Oct/Nov—Aug 7 Dec/Jan—Oct 7

AD TO READ:_____
If you need more space, type all of your copy on a separate sheet.

_____

_____

_____

_____

_____

NAME_____

COMPANY_____

ADDRESS_____

CITY_____

STATE_____ ZIP _____

PHONE_____

RATES*

FREQUENCY	1X	3X	6X
PER WORD	$11.00	10.50	10.00

_____WORDS AT $_____RATE=_____

**15 word minimum. Payment required with order.*

❑ DISCOVER ❑ VISA ❑ AMEX ❑ MC ❑ CHECK

CREDIT CARD NUMBER_____

EXP. DATE_____

CREDITS

The Return of the Lost Air Crew. Colonel William H. Jordan served as commander of the U.S. Army Central Identification Laboratory, Hawaii, from 1993 to 1996 and has been active in the POW/MIA program for 10 years. He retired from the Army last December after 31 years of service.

Mission Accomplished. Arnold Benson's last contribution to *Air & Space/Smithsonian* was "All That Jazz" (Flights & Fancy) in the Aug./Sept. 1997 issue.

The Thrill of Invention. Tom Crouch is chairman of the department of aeronautics at the National Air and Space Museum and author of *The Bishop's Boys*, a biography of the Wrights.

Photographer Tim Wright (no relation to the brothers Wilbur and Orville) took his turn at pulling gliders and leg muscles on the dunes. When it comes to falling face first, Wright reports dry sand is softer than wet.

Ken Hyde and Rick Young are seeking recollections and artifacts related to the Wrights. Anyone with something to share should contact Hyde at 7099 Glenn Curtiss Lane, Warrenton, VA, 20187, tel. (540) 347-1909 or Young at 10301 Jefferson Davis Highway, Richmond, VA 23237, tel. (804) 796-4733.

The 1902 Glider. Bruce Morser lives and draws on Vashon Island in the Puget Sound, just a short ferryboat ride from Seattle.

Fallen Arrow. Andrew Chaikin, a regular contributor to this magazine, makes an irregular acting debut in April in the HBO miniseries "From the Earth to the Moon." Look for him as the host of "Meet the Press" in the first episode. He is the author of *Air and Space: The National Air and Space Museum Story of Flight* (Bulfinch Press, 1997).

Further information: The Avro Arrow Home Page is at www.totavia.com/arrow

The Terminal Avro Arrow Obsession Syndrome Support Group is at studio.watertower.com/~coydog/taaos.htm

The National Aviation Museum is at www.aviation.nmstc.ca

The Outer Limits. California-based writer Heather Millar has written about science, the environment, and society for *Atlantic Monthly*, *Wired*, *Popular Science*, *Business Week*, and other publications.

Published in several hundred magazines, Michael Carroll's art has also

been exhibited aboard the Russian Mir space station. One of his paintings ended up at the bottom of the ocean, having been aboard Russia's ill-fated Mars 96 spacecraft.

Mean Machine. William L. Smallwood served in the U.S. Air Force and has logged over 4,000 hours flying Citabrias, Bonanzas, and Mooneys. An author of two books on aviation in the Gulf War, *Strike Eagle* (Brasseys, 1994) and *Warthog* (Brasseys, 1995), Smallwood lives on the Snake River near Buhl, Idaho.

During his week at Fort Polk, photographer Chad Slattery learned more than he wanted to about MREs (meals ready to eat). He can be reached on the World Wide Web at www.aeropix.com.

Up in Smoke. Long before he started launching rockets, Dan Kovalchik was tracking them. As a "range rat" in NASA's worldwide Satellite Tracking and Data Network, Kovalchik circled the globe aboard the USNS *Vanguard* and has committed his lighthearted observations to print in *Range Rats at Sea* (Commonwealth Publications, 1995).

The Battle of Midway, Round Two. Bill Marsano is a travel writer living in Manhattan.

Air & Space's Caroline Sheen began her career in photography in the fifth grade, when her family lived on Midway Island. Her first subjects, gooney chicks and red-tailed tropicbirds, are still among her favorites, and she still loves Midway.

Further reading: *Incredible Victory*, Walter Lord, Harper & Row, 1967.

The First Team, John B. Lundstrom, Naval Institute Press, 1984.

"A Glorious Page in Our History," edited by Robert J. Cressman, Pictorial Histories Publishing Company, 1990.

Remembrances of Things Pax. John Sotham is an associate editor at *Air & Space.*

"Radio the tower. We've been through some very weird crosswinds."

CALENDAR

April 18
Food-For-Life Drive. Eighteen aircraft open for inspection. Donations of non-perishable food sought for those in need. Hill Aerospace Museum, Hill Air Force Base, UT, (801) 777-6818.

April 18 & 19
Airshow of the Stars. Kissimmee Airport, FL, (407) 846-4884.

April 25 & 26
Spirit of Flight Airshow. Galveston Municipal Airport, TX, (409) 740-7722.

April 30–May 3
Reunion: 446th Bomb Group, 8th Air Force, World War II. Savannah Marriott Riverfront, Savannah, GA, (770) 972-5883.

May 2 & 3
Shell Air & Sea Show. Fort Lauderdale, FL, (954) 527-5600, ext. 88.

May 8–11
Hang Gliding Spectacular and Air Carnival. Jockey's Ridge State Park, Nags Head, NC, (800) 334-4777.

May 13–16
Formation Flying Clinic. Aircraft of all types welcome. Greenwood, MS, (601) 453-5646.

May 16 & 17
Santa Maria Celebration of Flight. Santa Maria Public Airport, CA, (805) 922-8758.

Warbirds Over Hickory Fly-In. Hickory Regional Airport, NC, (704) 437-0541.

May 21
Space Day. Events around the world include science fairs, field trips, art contests, and a live eight-hour Cyber Webcast featuring interviews with astronauts, scientists, space entrepreneurs, and futurists. For more information about Space Day activities, visit the World Wide Web at www.spaceday.com or call Devillier Communications at (202) 833-8121.

May 21–24
B-47 Stratojet Association Membership Meeting. Embassy Suites Hotel, Omaha, NE, (210) 653-5361.

May 23 & 24
Columbia Regional Airport Airshow, MO, (573) 443-2651.

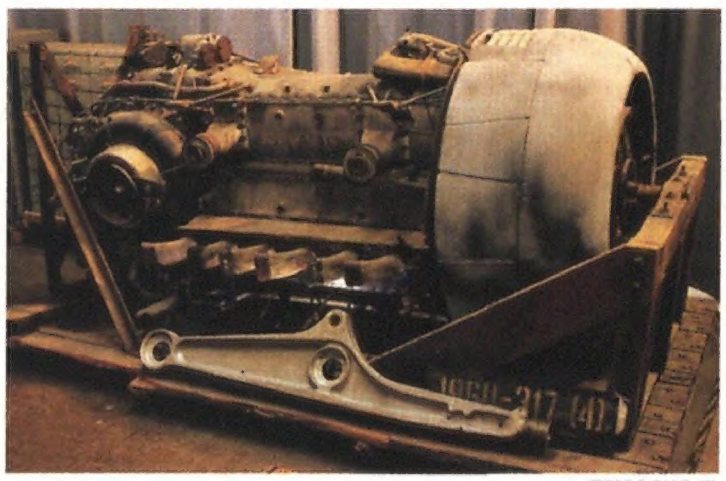
World's Smallest Airshow. Ultralight demonstrations and skydivers. Brian Ranch Airport, Llano, CA, (805) 261-3216.

ON THE WEB SITE

Tour the Garber Facility

Works-in-progress at the National Air and Space Museum's restoration facility include a Pitts Special (right) flown by aerobatic champion Betty Skelton, a Nieuport 28 biplane, an SA-2 surface-to-air missile, and a Pitcairn autogyro. See them all at www.airspacemag.com/ASM/Web/Special/Garber/Report.html.

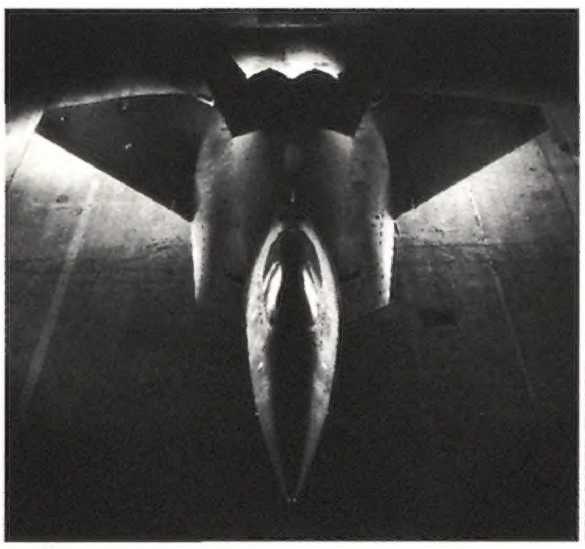
In preparation for the move to the Dulles Center, engines in the collection, like this Daimler Benz V-12, are also being restored. A selection is on view at the Web site.



ERIC LONG (2)

FORECAST

In the Wings...



ERIC SCHULZINGER

Alpha Jet. Yes, the Air Force's new air superiority fighter—the Lockheed F-22 Raptor—is fast and stealthy. But it's the Raptor's ability to hunt in packs that makes this fighter fearsome.

"Houston, er, Moscow, er, Tokyo, We Have a Problem." What will mission control be like in the era of the international space station?

Remembering the Lift. For 11 months in 1948-49, two million people in the Western sector of Berlin could receive food and supplies only by air. In the memories of the pilots who flew the airlift, it was a time of coal dust, little sleep, and "flying like hell."

Air Battle Over Manhattan. Who will win New York City's television ratings war: News Chopper 4, with its 20 mph edge, or News Chopper 2, featuring Infrared Cam? Stay tuned.

YOU Tell Bruce Willis He Can't Blow up an Asteroid. In the motion picture *Armageddon*, two advanced space shuttles launching simultaneously carry a team of oilfield roughnecks to an asteroid on a collision course with Earth. Could Bruce save our planet? Here's what the technical advisors say.

JOHN HEINLY

Remembrances of Things Pax

Places of discovery often become sacred ground: the sands of Kitty Hawk in North Carolina, the dusty expanse of Edwards Air Force Base in California. Maryland's Patuxent Naval Air Warfare Center, since World War II the U.S. Navy's premier center for testing new aircraft and weapons systems, is such a place.

As you drive to the center, several airplanes come into view, their fins resplendent in the bright swaths of International Orange that mark them as test aircraft. There's a North American RA-5 Vigilante, a Douglas A-4 Skyhawk, a McDonnell F-4 Phantom, a Grumman E-2B Hawkeye, and a Douglas F4D Skyray. The airplanes are chocked and tied down but not roped off; you can drive right up to them. You might think you'd taken a wrong turn and that you'd better keep your hands in plain sight and wait to be taken into custody. Now step away from the car...and enjoy a good, close look. The aircraft are exhibits of the base's museum.

The Patuxent River Naval Air Museum is devoted to the history of Navy flight testing. In addition to aircraft, the museum displays an eclectic mix of artifacts to document that rich past: jet engines cut away to show interiors, an F-4 cockpit trainer visitors can climb into, and, in a display on Navy test pilots who went on to become astronauts, a Mercury space capsule flight manual. Each object whispers a tale, and museum director Henry Bonner has made it his mission to present all of these stories as part of a larger narrative.

Bonner was hired last year, though not for his knowledge of aircraft or test flying. His background is in international marketing and public relations, and his last job was executive director of the Sotterley Mansion, a restored 18th century plantation overlooking the Patuxent River. "I'm learning—I now know what an A-6 is," Bonner says. But the G-suit-and-afterburner crowd shouldn't take him for a softie; during World War II, the Harvard-educated Bonner served with the British Eighth Army in North Africa and the Office of Strategic Services, the predecessor of the Central Intelligence Agency. After the war, he continued working in intelligence as a CIA cold warrior.

Since coming to the Pax River museum, Bonner has been overseeing a major transformation. Before his arrival, the museum had displays about various programs at the center and the pilots who died testing aircraft there, but the stories weren't presented in much of a historical context. The test pilot school at Pax River began in 1945 as an informal course held in small wooden barracks, and over the years the school has become part of what is today the Naval Air Warfare Center, with programs that evaluate ordnance, electronic systems, and carrier suitability. To document this and other aspects of the base's history, Bonner is creating an illustrated timeline stretching across an entire wall. He will also chart various Pax River advancements by using the museum's collection of airplane models. Bonner has many to choose from; most of the collection had been clustered without comment in several glass cases, the products of many sailors' spare hours. The museum also has some beautifully fashioned wooden wind tunnel models. Though Pax River has never conducted wind tunnel tests, the models illustrate the link between conceptual design testing and the final evaluation of actual hardware that the base specializes in.

Visitors to the museum will find Bonner all over the place—one minute explaining the negotiations necessary to acquire aircraft for the museum, then off to help run the cash register in the gift shop. Later, he'll stop to talk with a petty officer who wants to have his retirement ceremony next to the museum's Grumman A-6 Intruder, parked outside.

Bonner is aided by volunteers like Harold Bishop, who started working at Pax River in 1952 as an aircraft mechanic and now serves as the museum's handyman, working on lighting, painting, and whatever else needs help. Bishop designed and built the cabinetry for a recently created exhibit on radar featuring a 1944 system that was the first ever tested at Pax River. Former director Jack Nial, who still gives museum tours, and Harry Errington, who oversees the upkeep of the museum's aircraft, provide decades of U.S. Navy aviation expertise to complement Bonner's curatorial skills. Errington has been vital in procuring everything from ejection seats to entire aircraft—he was key to the museum's recent acquisition of an F-14 Tomcat.

As other bases shut down, the museum's scope of responsibility grows. When the Naval Air Development Center in Warminster, Pennsylvania, closed, it sent the museum enough boxes, papers, diagrams, and models to fill two rooms. One storage room is dominated by a huge medieval-looking chamber called the Iron Maiden, which will be featured in an exhibit on pressurization research. The Iron Maiden resembles an old-fashioned deep-sea diving suit cast in an eternal seated position; the helmet has a porthole-like face plate. Unfortunate test subjects were bolted into the contraption and subjected to experiments that, for now, remain a mystery.

Just when you've gotten caught up in some fascinating historical tale, a new F/A-18E or -F shrieks overhead, or you catch a glimpse of a V-22 Osprey tilt-rotor transitioning from vertical to horizontal flight as part of its test program. Even while the museum rethinks how best to showcase the past, test programs churn out new history for Bonner and his volunteers to commemorate.

—John Sotham

Patuxent River Naval Air Museum, P.O. Box 407, Patuxent River, MD 20670. Phone (301) 863-7418. Open Wed.–Sun., 12–5 p.m., except major holidays. (On June 1, 1998, the museum will begin a trial of operating Tues.–Sun., 10 a.m.–5 p.m.) Admission free.

PLANET EARTH
A COMMEMORATIVE EARTH DAY POSTER FROM THE APRIL 1990 SMITHSONIAN

The Poster measures 21¾" x 28¾"
Printed on Recycled Paper
Allow 4 to 6 weeks for delivery

Send $10.00 with address to:
Smithsonian Magazine, P.O. Box 23624,
Washington, D.C. 20026-0624

"We've never seen a better credit card!

By the way, what's a credit card?"

Davy Crockett
Even he couldn't have shot any holes in an offer this good.

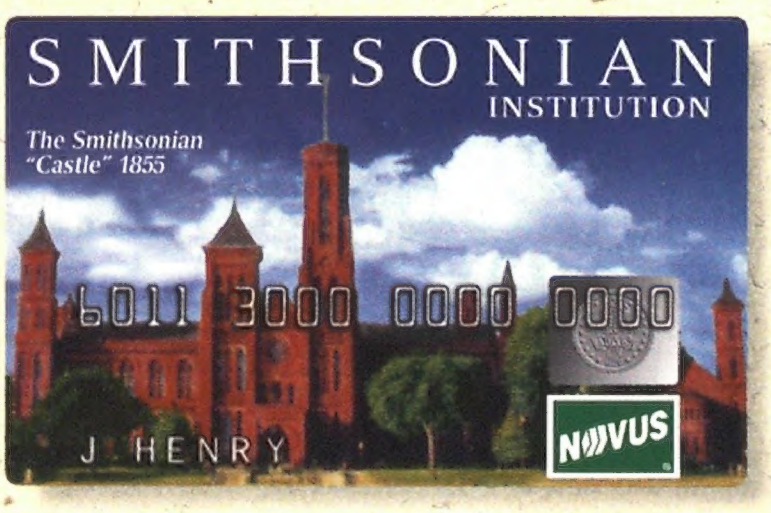
Susan B. Anthony
She fought to give women a voice. And only one card lets you voice your support for the Smithsonian.

Chief Joseph
He was a brilliant leader. And now you can lead the way in preserving his heritage.

It's Davy Crockett's credit card. And Susan B. Anthony's. In fact, it's the credit card of just about any historic American you can name. It's the Smithsonian Card.

Save For Your Future, and Support The Smithsonian.

Every time you make a purchase you'll help the Institution preserve America's past. And you save for your future too, because you'll earn points toward free U.S. Savings Bonds.* So apply today. There's never been anything like this before in the history of America.



To apply, call toll-free

1*888*33CASTLE

USE WHERE YOU SEE DISCOVER NOVUS